PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat. Office

SEMI-MONTHLY

VOL. XVIII. CHICAGO, JANUARY 15, 1914 No. 2

Control System for Panama Canal Locks

DETAILS OF THE ELECTRICAL EQUIPMENT MAKING POSSIBLE SAFETY AND PERFECT CONTROL OF THE CANAL LOCKS

ELECTRICAL SPECIFICATION, design and manufacture of the Panama Canal centralized control system may properly be regarded as one of those undertakings which, from an engineering standpoint, not only arouse a lively interest but also present an opportunity for much valuable instruction. The interest results mainly from the immensity of the Canal project itself, and the instruction from a consideration of the methods employed to insure the passage of even the largest ships afloat across the Isthmus with speed and safety. The complete operation of the Canal locks, terminals and auxiliary equipment utilizes electrical energy throughout, with the present exception of the Panama Railroad, the electrification of which is under contemplation.

Specifications for the entire generating, lock controlling and distribution system for operating the Panama Canal were prepared under the supervision of Edward Schildhauer, Electrical & Mechanical Engineer, Isthmian

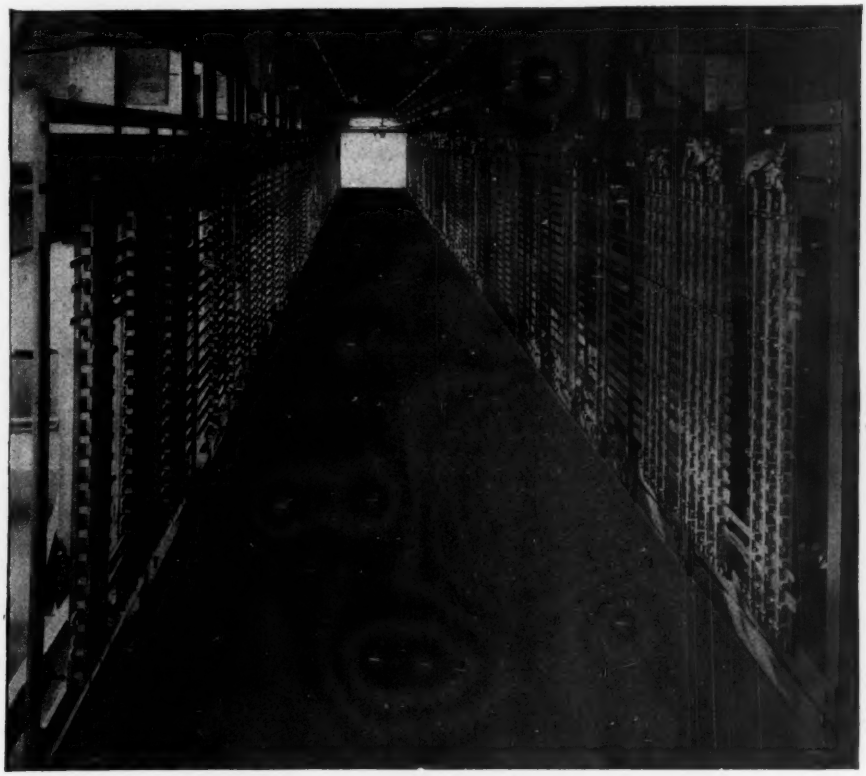


FIG. 3. INTERLOCKING SYSTEM BELOW THE MIRAFLORES CONTROL BOARD

Canal Commission, assisted by a staff of able electrical engineers, including C. B. Larzelere, who was closely identified with the lock control problems, and W. R. McCann with the generation and distribution of power. These specifications exhibited great care and painstaking engineering. They contained every safeguard that expert engineers could suggest, were exact and explicit in regard to the results required, yet gave proper range in the details of accomplishment.

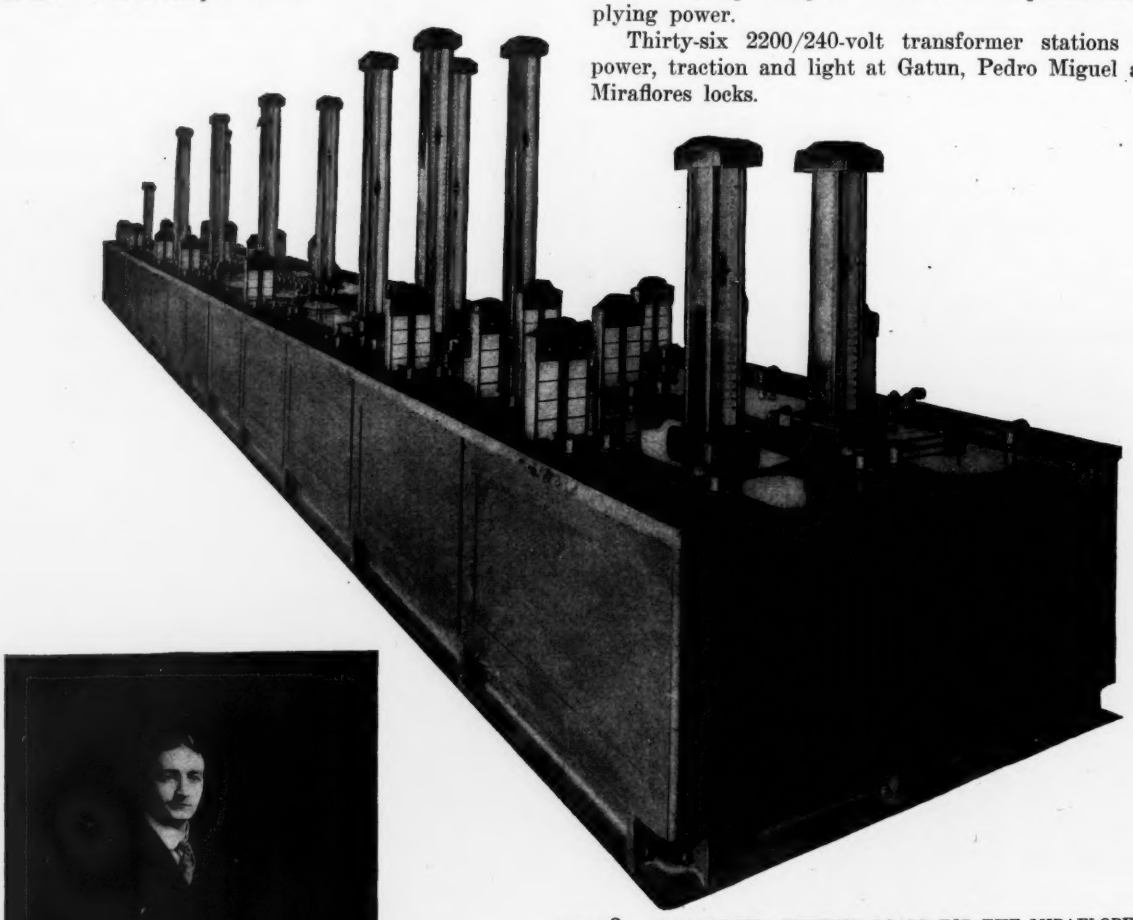


FIG. 2. CENTRALIZED CONTROL BOARD FOR THE MIRAFLORES LOCKS OF THE PANAMA CANAL

FIG. 1. EDWARD SCHILDHAUER, ELECTRICAL AND MECHANICAL ENGINEER, ISTHMIAN CANAL COMMISSION

Generation and Distribution

THE POWER system for the operation of the locks, towing locomotives, lights for the locks and buildings, and motors not directly connected with the lock control, is composed of:

A 7300-kv.a., 2200-volt hydroelectric power plant at the Gatun Dam.

A 4500 kv.a., 2200-volt Curtis turbo-generator electric power plant at Miraflores for emergency, lately used to supply power for construction work.

A double 44,000-volt transmission line across the Isthmus, connecting Cristobal and Balboa with the 2 power plants.

Four 44,000/2200-volt substations, stepping down at Cristobal and Balboa, and up or down at Gatun and Miraflores, depending on which of the 2 plants is supplying power.

Thirty-six 2200/240-volt transformer stations for power, traction and light at Gatun, Pedro Miguel and Miraflores locks.

Three 2200/220-110-volt transformer stations for the control boards at the locks.

Stations at Cristobal and Balboa for coal handling plants, machine shops and dry docks.

The system of connection throughout employs a double bus, double switch scheme, with provision for disconnecting any oil switch for cleaning or repairs without interrupting the circuit. In the power house and the 4 44,000/2200-volt substations, the oil switches are solenoid operated and are installed in concrete cells, above which are concrete fireproof compartments containing the 2 sets of buses. In the 36 transformer stations in the lock walls, the oil switches are hand operated. All 2200-volt oil switches have disconnecting switches, so arranged that live parts are completely covered.

For the hand operated switches, a pipe framework supports vertical metal guides which carry the oil switch

operating mechanism and slate base forming a section of the switchboard panel. On the guides a lever and toggle mechanism is mounted, by which the oil switch and slate base may be raised and lowered. Above the oil switch and mounted on the pipe framework a stationary cast-iron base carries the disconnecting switch studs and insulators. The high tension leads run to the tops of the disconnecting switch studs, and the bottom of each stud is equipped with contact fingers. On the top of each oil switch stud is mounted a contact blade. When the oil switch is raised, these blades engage the contacts on the bottom of the disconnecting switch studs, which thus in the closed position form extensions of the oil switch studs. The disconnecting switch contacts are surrounded by insulating shields which prevent accidental contact. When the oil switch is lowered, it is completely isolated from the circuit. When the oil switch is raised, it always goes to a fixed height where it is latched. An interlock prevents the oil switch from being raised or lowered unless its contacts are open, precluding the circuit being closed or opened by the disconnecting switch. In some instances another interlock makes 2 single-throw switches a double-throw switch and prevents both switches being closed at the same time.

For solenoid operated switches, the same form of disconnecting switch is used; but the solenoid is stationary and the connecting mechanism to the oil switch has a vertical slotted link which allows the oil switch to be raised and lowered without being disconnected from the solenoid mechanism. A mechanical interlock prevents the raising or lowering of an oil switch while in the closed position.

Instrument and control board for the Gatun Generating Station is of natural black slate, as are all the switchboards for the power system. It is totally enclosed by means of grille work with doors at each end. The switchboards for the transmission line substations are of the vertical type, with control apparatus and mimic connections symmetrically arranged on the middle section of the panels. The rear of the board is enclosed by means of grille work with doors at each end.

Power Supply and Control Panels for Lock Machinery Motors

Current for the lock machinery and towing locomotives is transformed from the 2200-volt system in the immediate vicinity of where it is used. There are a total of 36 transformer stations, for all locks, each containing duplicate 200 kv.a. 3-phase 2200/240-volt transformers for power and one single-phase 25 kv.a. 2200/220-110-volt transformer for lighting. The stations, normally fed from the 220-volt buses in the 44,000/2200-volt substations, can also be operated from the power plants; the stations at Gatun locks from the Gatun hydroelectric station; and the stations at Miraflores and Pedro Miguel from the Miraflores emergency steam plant.

To give an idea of the number and sizes of motors to be controlled in operating the lock machinery, the following table is interesting:

Machines and Operation	Motors each Machine and Hp.	Number of Motors Gatun	Ped. M.	Mira.	Tot.	Total Horsepower
Miter gate, moving, each leaf	1-25	40	24	28	92	2,300
Miter gate, miter forcing....	1- 7	20	12	14	46	322
Fender chain, main pump...	1-70	16	16	16	48	3,360
Fender chain, operating valve	1- ½	16	16	16	48	24
Rising stem gate valve.....	1-40	56	24	36	116	4,640
Cylindrical valve	1- 7	60	20	40	120	840
Guard valve	1-25	6	6	6	18	450
Auxiliary culvert valve.....	1- 7	4	4	4	12	84
Totals		218	122	160	500	12,020

There are many motors not included above, as, for instance, those for the spillway gates, for the hand rails on the mitering gates and for the sump pumps. The spillway gates are remote controlled from a special control board, and the control of the hand rail motors is given in connection with the discussion of mitering gates.

The motors are started and controlled by contactor panels located near them, the contactors of which handle the main motor currents. These contactors are controlled from the central control house. The smaller motors, including those for cylindrical valves, auxiliary

FIG. 4. CONTROL HOUSE AT GATUN FROM CENTER WALL SHOWING ALSO TOWING TRACK INCLINE BETWEEN UPPER AND INTERMEDIATE LOCKS

culvert valves and miter forcing, are started by being thrown directly on the line. Two double-pole contactors are used, one for forward and one for reverse. In the case of larger motors for miter gate moving, rising stem valves and guard valves, a starting point with resistance in 2 legs of the 3-phase circuit is provided.

In all cases the contactors are operated from the control boards—to be described later—by 3 wires, one for forward, one for reverse and a common return. In the case of panels having a starting point, the period during which the motor remains on the resistance is automatically controlled by a dashpot, so that the starting operation at the control house is the same, simply energizing a forward or reverse wire as the case may be. The control connections are arranged in such manner that each in-

dividual machine may be controlled locally. This arrangement provides for emergency operation should the control circuits from the central control house be out of order.

Location and Operation of Lock Machinery

From an operating standpoint the machinery was placed below the coping of the lock walls, thus affording a clear space for maneuvering ships and protecting the apparatus from the weather without erecting numerous houses.

The mitering gates consist of 2 massive leaves pivoted on the lock walls which operate independently of each other. A pair of gates is located where each change of level occurs and divides the locks into 1000-ft. chambers. In addition to these gates, at lake and ocean ends are duplicate pairs of gates used as guard gates. To handle the vessels of various sizes with the minimum use of water, mitering gates of the same description as those above are installed, dividing 1000-ft. locks into 2 compartments. These gates are termed intermediate miter-

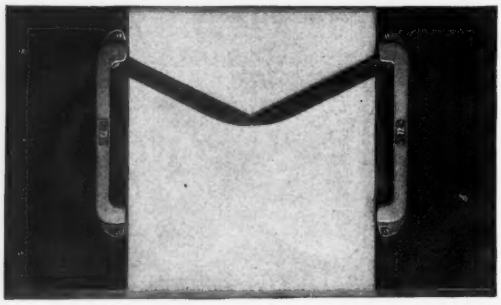


FIG. 5. MITER GATE INDEX

ing gates. When the mitering gates are closed they are what might be termed clamped in this position by a device called a miter forcing machine.

On the top of all mitering gates a foot walk with hand rails is provided. When the gates are opened and in the recesses provided for them in the lock walls, these hand rails would interfere with the passing of the towing locomotives, except in the case of the lower guard gates. The hand rails are therefore made to be raised and lowered. This is done by a motor under the foot walk, controlled from the lock wall. Near the approach to each foot walk a controller is located in the lock wall flush with the surface, this controller being operated by a foot push. If the gates are closed and the hand rails are down, and it is desired to cross on the gates, the foot push is pressed and the hand rails are raised by their motors. This is true not only of the hand rails on the nearer gate leaf, but of the hand rails on the farther leaf as well. After passing across, one can, if he desires, press the foot push on the other side and both hand rails will be lowered. Or, if one leaves the hand rails up and the gates are opened by the operator in the control house, they will be automatically lowered so as to be out of the way when the gate is in the recess. When the gates are again closed, the hand rails will automatically rise again if the foot controller has been operated in the meantime. The hand rails cannot be raised when the gates are opened, and no harm results if the foot switch is operated while the gates are in the closed position.

The chain fenders are stretched across the canal in front of all mitering gates which can be exposed to the upper lock level and also in front of the guard gates at the lower end. These chains are maintained in a taut position when the gates behind are closed, and are lowered when the gates are opened for the passage of a ship. The chains are raised and lowered by a method similar to that followed in hydraulic elevators, with the additional feature that if a ship approaches the gates at a dangerous speed and rams into the chain, the chain is paid out in such a way as gradually to stop the ship before it reaches the gates. Lowering the chain for the passage of a vessel and raising it again after the vessel has passed is accomplished by 2 motors; one driving the main pump supplying water under pressure, and the other operating a valve which controls the direction of movement of the chain. These 2 operations are combined in one, each motor being stopped automatically by a limit switch when the motor has performed its function.

Filling and emptying of the locks is accomplished by 3 culverts, one in the middle wall and one in each side wall, the flow of water being controlled by rising stem valves. They are located in the culverts at points opposite each end of each lock so that the culvert can be shut off at any desired point for filling a lock with water from above, or upstream, or for emptying it by allowing it to flow out and down to the next lock. Lateral culverts conduct the water from the main culverts, under the lock chambers, and up through openings in the lock floors.

The rising stem valves are installed in pairs, and each pair is in duplicate; also each culvert is divided into 2 parallel halves at these valves by a vertical wall. This arrangement reduces the size of each valve and makes it more easily operated, each valve being 8 by 18 ft. One pair of duplicates is left open as a guard, or reserve pair; the other pair is used for operating, so that in case of an obstruction in the culvert or accident to the machinery, the duplicate pair can be used.

At the upper ends of the culverts at the side walls, the duplication is accomplished by 3 valves in parallel, called the guard valves. They perform service exactly similar to the rising stem valves, except that 3 valves in parallel in this case must conform to the same laws as the 2 in parallel in the other case.

Culvert in the middle wall must serve the locks on both sides, and to control this feature cylindrical valves are placed in the lateral culverts that branch out on each side. There are 10 of these on each side of the culvert at each lock.

At the upper end of each set of locks, there are 2 valves in the side wall for regulating the height of water between the upper gate and upper guard gate, as it is desired to maintain the level of the water between these gates at an elevation intermediate between that of the lake above and that of the upper lock when the upper lock is not at the same level as the lake. These valves are called the auxiliary culvert valves.

Reasons for Using the Control System Adopted

As the flight of locks at Gatun, for instance, extends over approximately 6200 ft., and the principal operating machines are distributed over a distance of about 4000 ft., it can be readily seen that central mechanical transmission of control of machines would be almost impossible; and to control the machines locally would mean a large operating force distributed practically along the full length of the locks, which has invariably been the practice heretofore. Such a force would be difficult to co-ordinate into an efficient operating system. The situation therefore resolved itself into centralized electrical control, which reduces the number of operators, operating expense, and liability to accident. To accomplish this system of control, a control board for each lock was constructed which permitted having all control switches located thereon mechanically interlock so as to minimize, if not entirely prevent, the errors of human manipulations.

Centralized Control and Indicating System

Control boards are installed in control houses located on the middle walls at points which afford the best view of the locks, although this view is not depended on to know the position of the gates or other apparatus, as all are provided with indicators on the control board. The control boards are made approximately operating miniatures of the locks themselves, and are arranged with indicating devices which will always show the position of valves, lock gates, chains and water levels in the various lock chambers; and with the exception of such machinery as needs only an "open" or "closed" indication, the indications will be synchronous with the movement of the lock machinery.

For such indication, appliances with commutators, multiple contacts or ratchet mechanisms would not be suitable because of the many contacts and small pieces in their construction; and particularly because devices of this character move step by step and would not indicate all points in the movement of the main machinery, such indications being more or less approximate according to the number of steps in the indicating devices. The indicators on the Panama control boards were developed especially for this undertaking, and show accurately and synchronously every movement of the machinery to which they are connected, whether in the extremes of travel or at any intermediate point.

A complete synchronous indicator consists of a transmitter located at and operated by the machine in the lock wall, and a receiver operating an indicator at the switchboard in the control house. Both transmitter and receiver have a stationary and a rotating part. The stators have 3-phase windings with leads from 3 corresponding equidistant points brought out and connected together, but not connected to a source of power, the stator coils being energized by induction from the rotors. The rotors are bipolar and are connected in multiple and energized from a 110-volt, 25-cycle single-phase source.

The movement of the lock machinery and with it the connected transmitter rotor produces a field in the transmitter stator polarized in the direction of the rotor axis, which induces voltage in the stator coils. This voltage is transmitted by the 3-phase connection above mentioned to the receiver stator coils and duplicates in them but in the reverse direction, the same conditions of polarity and voltage as present in the transmitter. The rotor of the receiver being energized by the external source in the same direction as that of the transmitter is reacted upon by the polarized receiver stator until the magnetic axes coincide and the rotors of both transmitter and receiver are in the same relative position. Any difference in the position of the transmitter and receiver rotors causes a difference of potential between the stator

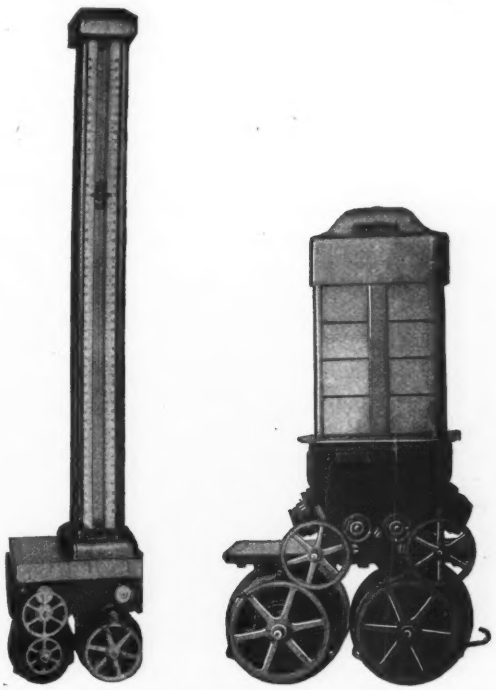


FIG. 6. WATER LEVEL INDICATOR
FIG. 7. RISING STEM VALVE INDICATOR

windings with a consequent flow of current and resultant torque, which again moves the receiver rotor to the same relative position as that of the transmitter rotor. The receiver rotor follows closely and smoothly the movement of the transmitter rotor, and consequently imparts to the position indicator a movement identical with the movement of the lock machine, although on a scale reduced to the requirements of the control board. A brief description of the individual synchronous indicators follows.

In the case of the mitering gates, the vertical operating shaft is connected to a shaft which operates the transmitter machine. The latter shaft is threaded and carries a nut on which is mounted a rack. The rack engages a gear on the rotor shaft, and this turns the rotor as the gates operate. The mitering gate indicator comprises a pair of aluminum leaves, shaped to correspond to the plan view of the top of the gate, which travel horizontally just above the top of the board, the hinge ends being connected to shafts extending down through the surface of the board where they are geared

(Continued on page 158.)

Laying Up The Plant

METHODS EMPLOYED IN A WELL ORGANIZED PLANT FOR KEEPING MACHINERY IN BEST OF CONDITION WHILE OUT OF SERVICE DURING SUMMER MONTHS. BY J. C. HAWKINS

THERE are some power plants in which on account of the existing conditions it is found advisable to lay the plant up for part of the year. This includes some isolated plants in which on account of the heating system being shut off the exhaust steam is not used, and it is cheaper or at least more desirable to purchase central station current through the hot months. Or the nature of the use of the power may be such that it is not required the year around, or for some other reason the power plant is to be closed down for some time.

When shutting down time comes it is possible, of course, simply to pull the switches and draw the fires, and leave the plant until wanted, then find everything in bad condition and not ready to start. The proper way as well as the cheapest in the end is to put the entire plant in first-class condition when shutting down, as it is much easier to do repair work then, than with everything hot or in the hurry of starting up.

It has been found desirable in the plant with which the writer has been connected during the past few years, to close the plant down during the hot months, and use central station, not from the point of cost per kilowatt, but as all the men are given a month's leave with full pay during this time, some extra help would have to be hired if the plant was kept in operation. Also, there is usually some overhauling and repairing to be done. The method of laying up the plant, and making repairs has been carefully worked out, along these lines.

During the months that the plant is in operation, little is done other than to keep the plant in good running order, and make only the necessary repairs. This does not mean that the plant is allowed to run down, but the object in view is economical operation when running, under the existing conditions.

SHUTTING DOWN THE HEATING SYSTEM

NOTES ARE made of any matter that seems to require attention during the idle period, and filed for future use. When the heating period is over all the steam lines and radiators are drained. This is partly a hot water system which is also drained and dried out by allowing air to circulate through it. The return pumps are taken apart and the valves, valve seats, and cylinder walls are given a coating of graphite and cylinder oil and the heads and covers are replaced with new gaskets, ready for operation. All piston rods, valve stems and other finished parts are given a coating of grease to prevent rusting, and all stuffing boxes including the water piston are repacked. The traps and tanks are cleaned out and all valves repacked. When laid up in this way the system is ready to be started up in a few minutes if necessary.

The end of the heating system allows part of the boilers to be taken off as less steam is required. As soon as the boilers, which are of the water-tube type, have been cooled down, the water is drained out and the turbine cleaner run through the tubes to remove the scale, also the scale is chipped off the drums and headers. The boilers are also cleaned during the heating season, but not so thoroughly as at this time. The accumulation of soot and ashes on the tubes and drums is brushed off and the combustion chamber is cleaned as well as the furnace and ash pits. At this time any repairs that are needed to put the plant in first-class repair for the next year, such as grate bars, stoker repairs, leaky pipe joints, leaky or bagged tubes, damper repairs, etc., are made.

CHANGING TO CENTRAL STATION SERVICE

AFTER CHANGING over to the central station current the engines, pumps, and the rest of the boilers are laid up. The boilers are cleaned as above stated, also the smoke breeching, which is a long one. The water columns are given a rigid examination, and also the fusible plugs.

The boilers each have 2 safety valves, one a locked up pop, and the other a lever valve. Both are taken apart and oiled, and are reset after starting up the plant by the chief, who keeps the key to the pop valve, thus preventing them from being tampered with by unauthorized persons.

After being cleaned and repaired the boilers are given a thorough examination by the chief engineer both internally and externally, the main object being to note any defects such as pitting, corrosion, defective brick work or anything else that the regular examinations made while the plant is in operation failed to disclose. A written report is made in which the conditions are compared with the conditions the year before, a copy of which is kept on file by the chief engineer, for reference.

The cleaning and repairing is usually done by the firemen together with bricklayers, and such other mechanics as are required. While this is going on in the boiler room the engine room force is overhauling the engines and pumps. The cylinder heads and valve bonnets are taken off and the valves and cylinder given a coating of graphite and oil. Sometimes the pistons are taken out for examination and repair of the rings, but if the records show that there is little leakage they are not taken out. In order to dope the full length of the cylinder the crank is placed on the crank end center, and the cylinder walls painted. Then the engine is turned over 2 or 3 times, more graphite being added, which is worked into the rings and to the walls under the piston when on the center.

The crank and wristpin brasses are taken out and repaired if necessary, also the crosshead shoes. The main bearing is taken apart and the oil ways examined and recut if required, and in reassembling the shaft is

re-alined, which is done by measuring from "alinement spots" on the inside of the frame to the crank disk, liners being used back of the back quarter box if required.

Governor and valve gears are taken down and the bearings examined and repaired if necessary. The outboard, which is ring oiling, seldom needs any other attention than new oil. The oiling system is cleaned out and washed out with gasoline, and all bright parts are coated with grease to prevent rusting. As this plant is intended as a show place as well as a power plant there is an exceptional amount of bright work including polished flywheel rims, etc., all of which are greased during shut-down. The metallic packings on the piston rods and valve stems are not removed unless repairs are necessary, as it is a difficult matter to re-assemble them exactly as they were on the rod before, and they are liable to leak if changed; but a generous supply of graphite is worked in along the rod to prevent rusting.

The boiler feed pumps, stoker engines, steam driven fire pump, vacuum pumps, and house pumps are opened for inspection and repairs, and the wearing surfaces are doped with graphite and oil. The valves and valve seats in the water end are examined and reseated or new ones put in if required. All parts are repacked and new gaskets used wherever a joint is broken. All valves on the high and low-pressure steam lines, air and water lines from the largest to the smallest, about 2500 in all, are repacked and reseated or repaired if necessary. Here is where the M. & D. reseating machine has proved its worth. The pipe covering is repaired and repainted (white in this case) as are the engine and boiler room walls.

Experience covering several years shows that few of the valves have had to be repacked or repaired during the months that the plant is in operation, and when it is necessary to close a valve the operator is sure that it is going to close tightly. If there are any of the pipe joints that show evidence of leakage new gaskets are put in. Nearly every year some small changes are made, and the material is gotten on hand before wanted so that no time will be lost in waiting for parts.

The exhaust steam building heaters for the hot water system oil separating tanks, hot water service heater, feed-water heater, blowoff tanks, traps, etc., are cleaned and repaired when repairs are required, also all steam gages, vacuum gages, water and air gages are taken off and tested by means of a gage tester.

New diaghragms are put in all feed-water regulators, pump governors, damper regulators, reducing valves and regulating valves, which are ground in or reseated if required, and set after the plant is put in operation.

After thoroughly going over the plant in this manner it is in first-class condition to stand idle indefinitely, and the men then get their well-earned vacation at the expense of the owner. Part of them return in time to relieve the others, as someone must be kept on duty to run the ice machine, vacuum cleaner, fire pump, ventilating fans, etc. While the plant is in operation there is practically nothing to do except to operate, and the undivided attention may be given to this matter.

From a financial standpoint, it would be cheaper to run this plant the year around than to buy outside current during the summer; but the management has more than the average amount of respect for the employes, and is willing to show its appreciation for good work, and incidentally to keep the plant in the best condition. There are no vacancies, but a waiting list of applications large enough to man a dozen power plants of this size.

Heating and Ventilating Large Buildings

TEMPERATURE REGULATION. BY CHARLES L. HUBBARD

EVERY heating plant in which a close regulation of temperature is desired, should be provided with automatic means, of some form, for producing this result. Not only does this add greatly to the comfort and convenience of the occupants of the building, but also results in a considerable saving in fuel when live steam is required for supplementing the exhaust. When temperature regulation is under the control of the occupants, the chances are that if the room becomes too warm the window will be opened instead of the radiator being shut off, and the surplus heat wasted. When there is ample exhaust steam, it is as well for it to pass outbound through the windows as through the main exhaust pipe; but if live steam is used, this represents just so much waste of fuel.

There are a number of devices upon the market for automatic temperature regulation, among which the Johnson and the Powers systems are the most widely used in buildings of large size, and for this reason, will be used for purposes of illustration in the present article.

A system of temperature regulation consists of 3 principal parts, or divisions, as follows: An air compressor, reservoir, and distributing pipes; thermostats placed in the rooms or spaces to be regulated; and special pneumatic valves upon the radiators, or diaphragm attachments at the mixing dampers.

Figure 1 shows in diagram the relation of the different parts, and illustrates the principle of operation. An air pressure, usually about 15 lb. per sq. in., is automatically maintained in the reservoir by means of a special compressor. From here a pipe leads to the thermostat, which is placed in the room to be regulated, and from here another pipe is carried to a pneumatic valve which takes the place of the usual hand valve upon the radiator.

When the temperature of the room reaches the point for which the thermostat is set to operate, the expansion of a metal strip, or the vaporization of a volatile liquid, opens a small valve and allows the compressed air to flow from the reservoir through the thermostat to the pneumatic valve, thus closing it and shutting off

steam from the radiator. When the temperature of the room falls, conditions are reversed, and a small exhaust valve is opened in the thermostat, which allows the air to escape from the pneumatic valve.

As the pressure above the diaphragm is removed, the valve opens, and allows steam to pass into the radiator

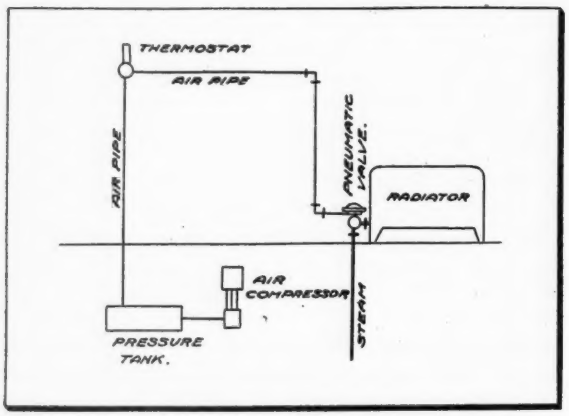


FIG. 1. DIAGRAM ILLUSTRATING PRINCIPLE OF TEMPERATURE-REGULATING SYSTEM

again. When the rooms are heated by warm air instead of direct radiation, the thermostat is connected with a diaphragm motor, so called, which operates a mixing damper, thus varying the proportions of hot and tempered air, and so changes the temperature of the air admitted to the room.

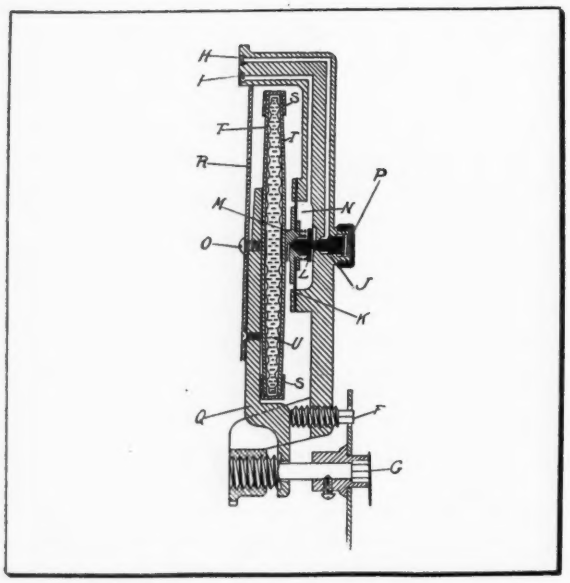


FIG. 3. SECTIONAL VIEW OF POWERS THERMOSTAT

One form of mixing damper, for use in the double-duct system, where one pipe is directly below the other, is shown in Fig. 2. The dampers in this case are attached to a common spindle, but at right angles to each other, so that when one opens the other closes. The diaphragm and its operating mechanism are shown at the bottom of the cut.

Mixing dampers of special form are also placed in the main air way between the fan and heater, and operated by a thermostat located in the duct beyond the

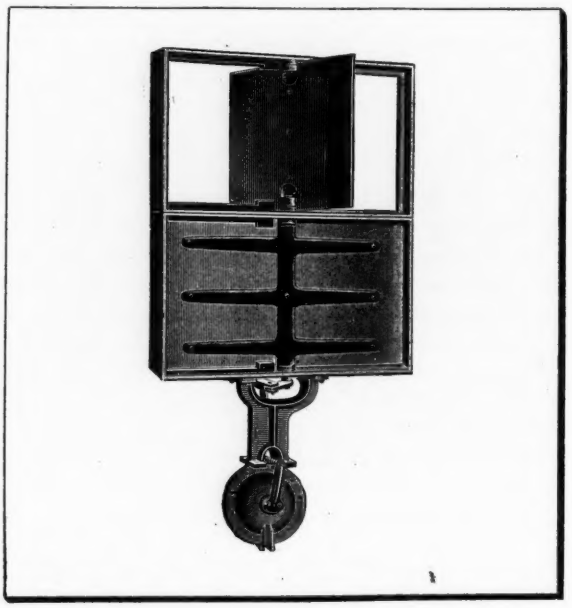


FIG. 2. MIXING DAMPER FOR USE IN DOUBLE DUCT SYSTEM

heater, thus giving automatically a constant temperature to the air delivered to the rooms for ventilating purposes.

THERMOSTATS

A THERMOSTAT, as already stated, is a device for controlling heat sources by valves or other means, and is actuated by changes in the temperature of the air in which it is placed.

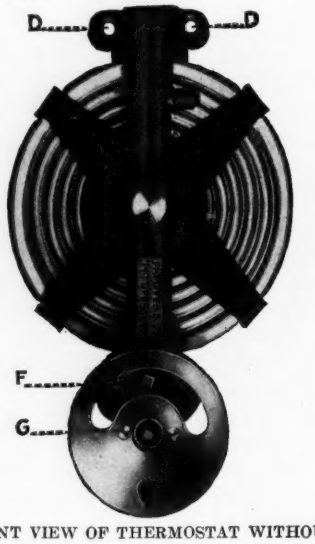


FIG. 4. FRONT VIEW OF THERMOSTAT WITHOUT CASING

A section through the Powers thermostat is shown in Fig. 3, and a front view in Fig. 4. In this case the small valves are operated by an expansion disk, consisting of 2 corrugated circular pieces of metal joined at the edges and stiffened by flat steel springs, as shown

in Fig. 4. The interior of the disk contains a volatile liquid having a boiling point of about 50 deg. F. The vapor thus formed has a pressure of about 6 lb. per sq. in. at a temperature of 70 deg. F., and changes with every variation, thus increasing or diminishing the thickness of the disk.

Referring to Fig. 3, U is the expansion disk, M a movable flange attached to a flexible diaphragm and operating the valve J, L is the exhaust valve, and H and I the pipe connections with the pressure reservoir,

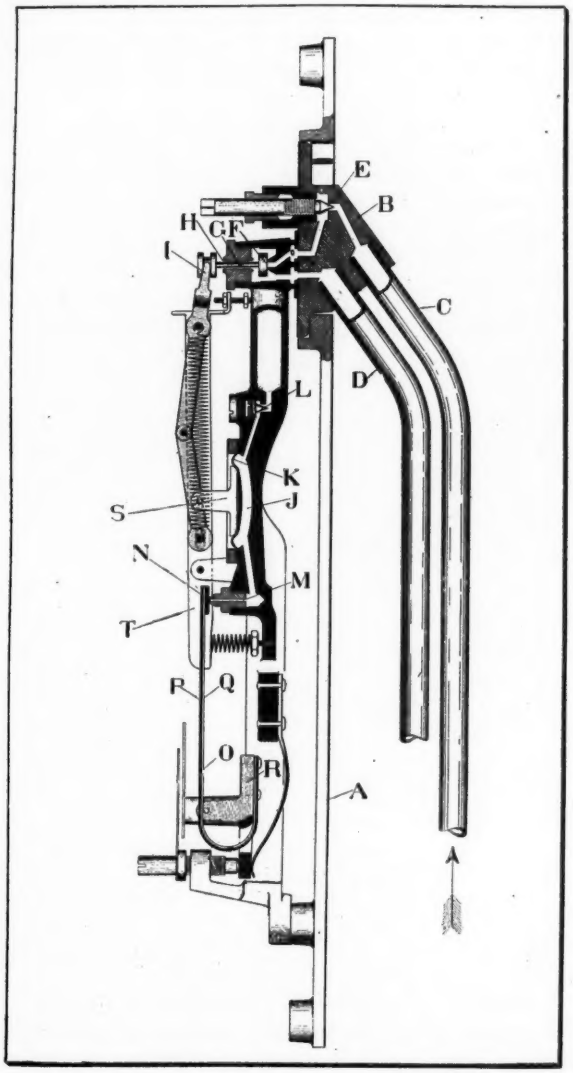


FIG. 5. SECTIONAL VIEW OF JOHNSON THERMOSTAT

and valve or diaphragm, respectively. When the temperature rises, the disk, U, expands, pressing against M and thus opening valve J. This allows the air to pass from H into J through chamber N, and thus admits the pressure to the steam valve or motor and closes it. When the temperature falls, the disk contracts, and the valve, J, is closed by the action of a coil spring. The air is relieved from the diaphragm of the valve or motor through the small exhaust valve, L.

This thermostat may be arranged to give either a graduated or positive motion to the diaphragm. In the case of mixing dampers and the valves on hot water radiators, the former is used, while for a steam valve it is desired to have it either wide open or closed, so that a positive motion is required. The thermostat just described and shown in Figs. 3 and 4, is for a graduated motion, but a positive motion may be secured by the addition of an accelerating valve.

A section through the Johnson positive thermostat is shown in Fig. 5. In this case, O, which is actuated by changes in the temperature of the air, is composed of 2 metal strips, one of brass and one of steel, soldered together and bent in the form of a U. One end is fastened rigidly at R, while the other forms a valve which closes the opening at N. C is the pipe leading to the pressure reservoir, and D to the valve or motor diaphragm.

F is a valve which, in the position shown, closes the connection between C and D, and places D in communication with the atmosphere through H, around the loose valve stem, G.

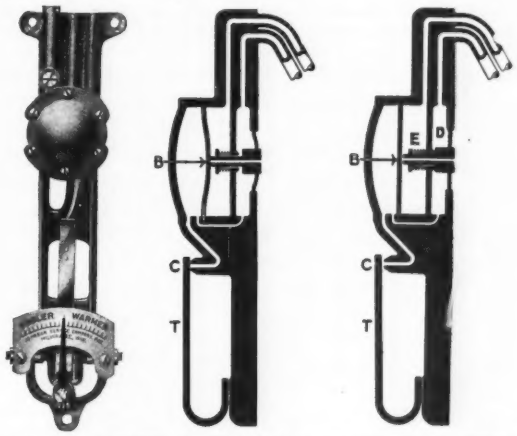


FIG. 6. GRADUATED THERMOSTAT, FRONT VIEW, CROSS-SECTIONS SHOWING CLOSED AND OPEN POSITIONS

J is a chamber in connection with pipe C at all times; K, a rubber diaphragm which, when forced out by a pressure in J, holds the valve F in the position shown, by means of connecting levers and springs.

L is an adjustable valve which allows the air pressure to leak slowly from pipe C into chamber J. Under the conditions shown, the steam valve at the radiator is open, the space above the diaphragm being in communication with the atmosphere through the pipe D and exhaust valve, H.

Suppose the temperature in the room rises above the point for which the thermostat is set. This will cause the metal strip, O, to expand and open valve N, thus exhausting the air from J and allowing the diaphragm K to move to the right. This throws the valve F to the left, closing the exhaust at H and allowing air pressure to pass from C to D, thus closing the steam valve at the radiator. While the valve is closed there will be a slight leakage of air past L and through N.

The graduated thermostat of the Johnson system is shown in section and front elevation in Fig. 6. This operates on the principle of a reducing valve, varying the pressure on the main diaphragm by an auxiliary valve thermostatically controlled. As this pressure varies, the mixing damper will be thrown open more and more as conditions may require.

A special form of duct thermostat is employed for maintaining a uniform temperature in the main ventilating duct leading from the fan. Thermostats of this general type are attached to the side of the duct, with the stem extending inward, and are designed both

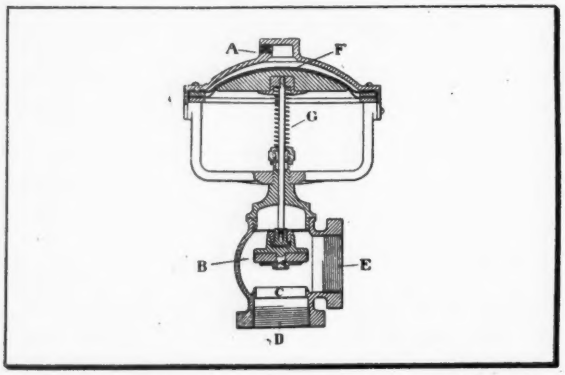


FIG. 7. SECTIONAL VIEW OF DIAPHRAGM RADIATOR VALVE

for operating mixing dampers upon the graduated principle and for controlling the steam valves upon the main coil.

VALVES

THE JOHNSON radiator valve, in section, is shown in Fig. 7. In this cut, D is the inlet from the steam riser, E the radiator connection, and B the valve for closing the opening C. Air pressure from the thermostat is admitted at A into the space above the flexible

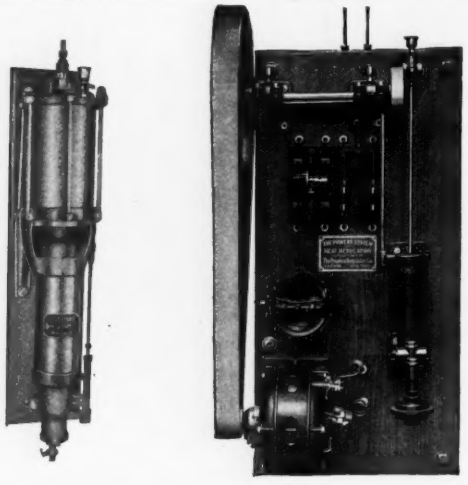


FIG. 8. HYDRAULIC AIR COMPRESSOR FOR THERMOSTATIC SYSTEM

FIG. 9. MOTOR-DRIVEN AIR COMPRESSOR

diaphragm F. When the pressure above the diaphragm is exhausted the valve is raised by the coil spring, G, around the stem.

In case of large valves 2 or more coil springs are used, set in a circle concentric with the stem.

AIR COMPRESSORS

THE AMOUNT of compressed air required for operating the valves and motor diaphragms in a system of temperature regulation is small. The compressors are automatic in action, maintaining a constant pressure in the reservoir or tank, and are driven either by water pressure, steam, or electricity, although belted compressors are sometimes used in the case of manufacturing plants.

A hydraulic compressor is shown in Fig. 8 and is similar in principle to a direct-acting steam pump, in which water, under pressure, takes the place of steam as the motive power. This type of compressor is adapted to buildings of comparatively small size, such as dwellings, churches, small schools, etc. In large plants it is best to employ steam or electricity as the motive power. An electrical outfit is shown in Fig. 9.

In any case, it is desirable to install all compressing apparatus in duplicate, as the entire outfit is dependent upon this part of the equipment.

In some cases, like large schools and churches, it is best to install both steam and water compressors, the first for general use during the heating season when the boilers are in service, and the second for use in operating pneumatic dampers during the summer season when there is no steam upon the building.

Melting Point of Commercial Copper Alloys

AS little information on the melting points of commercial brasses and bronzes can be found in either scientific or technical literature, tests of a few typical alloys were made by H. W. Gillett and A. B. Norton of the U. S. Bureau of Mines. The results, summarized, in Technical Paper No. 60, are as follows:

Alloy	Approximate Composition Copper	Zinc	Tin	Lead	Melting Point Deg. C.	Deg. F
Gun metal	88	2	10	..	995	1825
Leaded gun metal...	85½	2	9½	3	980	1795
Red brass	85	5	5	5	970	1780
Low-grade red brass.	82	10	3	5	980	1795
Leaded bronze	80	..	10	10	945	1735
Bronze with zinc....	85	5	10	..	980	1795
Half-yellow, Half-red	75	20	2	3	920	1690
Cast yellow brass ...	67	31	..	2	895	1645
Naval brass	61½	37	1½	..	855	1570
Manganese bronze...	..	..	..	..	870	1600

The melting point given is the "liquids," or point where the alloy is completely molten. The temperatures are thought to be accurate within plus or minus 10 deg. C., or plus or minus 20 deg. F.

Copies of this technical paper may be obtained by addressing the Director, Bureau of Mines, Washington, D. C.

TRADE EDUCATION must eventually revert to a form of modified apprenticeship through co-operation between school and plant, for 2 reasons; first, any other method will involve a great expense to tax-payers, for cities cannot duplicate mercantile and industrial plants without big capital outlay, and such plants alone can provide the framework for comprehensive plant instruction. Second, the education of people in a school in order to make them efficient workers is out of date, and even for those fields of education which lie outside of industry, education for life must in modern specialization be by working at the special job for which a man is preparing himself.

About Drafts and Draft Troubles

How Air Leaks, Friction in Gas Passages and Excess Air Supply Overload the Chimney and Waste Coal. Relation of CO_2 to Preventable Loss and Use of Draft Gage to Improve Combustion and Avoid Smoke. By Joseph W. Hays

OWNERS and engineers of power plants are frequently heard complaining about the "draft" and saying all manner of unkind things about the chimney. Most steam plants suffer from too much draft, rather than from too little. In about 4 cases out of 5 the causes of the draft troubles are to be found down in the boiler room, the chimney being in no way responsible for them. When the engineer talks about "lack of stack capacity," the real trouble may be a lack of engineering "sagacity." It will, therefore, be well to discover whether the fault is with the chimney or the engineer before sending for a brick mason to build a few more stories on top of the chimney. You probably have chimney enough and draft enough. What you really need is draft regulation.

By way of making clear what I am trying to convey, let me present an illustration. Let us suppose a farmer wishes to take a load of grain to market. He has been out in the field with a wagon, picking up "nigger heads" and other impediments to cultivation. He gathers just about all that the horses can draw, but the load does not fill the wagon box. Being a lazy individual and being in a hurry to get to town and cash in on his grain, he does not unload the nigger heads. He piles the grain in on top of them and of course he gets stuck going up "Sugar Creek hill." I submit that it would not be fair in such a case to blame the horses. The Society for the Prevention of Cruelty to Animals should get after the farmer, and a commission to determine lunacy should sit upon him. Undoubtedly both of these things would happen.

Good engineering is just good horse sense. When the capacity of either a horse or a chimney, to do useful work, is reduced by the performance of useless work, somebody is not exercising horse sense.

For formulas and other data relating to chimneys, the reader is referred to Kent's Handbook or to the catalogs of any of the leading boiler companies, which may be had for the asking, and in which the standard tables of chimney dimensions, etc., will be found. Most readers of this magazine already have chimneys "on their hands," so to speak, and accordingly, the vital question is not "What causes draft;" but rather, "Why is the draft deficient?"; not "How should a chimney be built?" but rather, "How can I make this chimney answer my purposes and avoid the expense of a new one?" The chimney now hitched to your power plant is your present problem, not the one that you might have built or the one that you may build when you tear down this one.

I have investigated a great many cases where poor draft was alleged and in most cases I have found the chimney pulling about 5 tons of nigger-head ballast for every ton of real cargo. And in nearly every case it has been possible to increase the effective draft greatly by throwing out the ballast. In some cases it has been necessary to make certain alterations in the flue connections, but in few cases has it been necessary to do anything to the chimney proper, beyond ordinary repairs.

What Causes Chimney Draft?

The force that is trying to go up the stack is stronger than the force that is trying to go down the stack. Chimney draft is caused by a difference in pressure or forces—the pressure that is trying to come down the stack and that which is trying to go up the stack. The flow of air or gas in the chimney is in the direction of the greater pressure and when the pressures are equal there is no flow at all.

Suppose, by way of further illustration, that we insert a glass tube in a bottle of oil. By closing the tube with the finger, we can lift out a tube full of oil. We next insert the oil-filled tube in a vessel of water and remove the finger. Water flows in at the bottom of the tube and pushes up the oil. The water in seeking its level exerts an upward pressure in the bottom of the tube that is greater than the downward pressure of the oil. Oil, being lighter than water, will rise to the surface of water.

Let us suppose again that the oil-filled tube is 6 in. long and that we push it down until the bottom end is 3 ft. under water before removing the finger. We shall then have a downward pressure at the bottom of the tube of 2 ft. 6 in. of water plus 6 in. of oil. There will be a pressure upward, at the bottom of the tube, of 3 ft. of water. This would make the net upward pressure at the bottom of the tube exactly equal the difference between the weight of the oil in the 6-in. tube and that of a corresponding 6-in. tube full of water.

Oil is lighter than water. Hot gas is lighter than cold gas. Air is a mixture of gases. Your 100-ft. chimney full of hot gas stands at the bottom of a sea of air some 50 mi. deep. Exactly as in the case of the water and the oil, the upward pressure at the bottom of the chimney exactly equals the difference between the weight of the column of hot gas in the chimney and that of a column of cold air of equal height outside the chimney.

From these illustrations it will be seen that draft is not an upward "pull" as its name implies. It is an upward "push," and to make it continuous, we have only to keep on introducing hot gas at the bottom of the chimney as fast as the preceding hot gas flows out at the top. By continuously making hot gas in the boiler furnace we may have a continuous upward flow of gas in the chimney with which the furnace is connected. The chimney must, of course, be large enough to carry off these hot gases as fast as they are produced or there will be real "simon pure" draft trouble. But before we are warranted in spending a lot of money for a bigger chimney, we must see about the "nigger heads" and other ballast that we are compelling the chimney to lift from the level of the furnace grates to the top of the stack.

Effect of Cold Air

Suppose we take a balloon and fill it with hot air. It will rise, of course, just as a light stick of wood will rise in the heavier water. Now, suppose we fill the balloon one-quarter full of hot air and three-quarters full of cold air. The upward pull or the "draft" of that balloon will be just one-quarter what it would have been if entirely filled with hot air. To increase your stack draft keep the cold air ballast out of the chimney, because draft depends primarily upon the temperature of the gases in the chimney.

But how can cold air get into the chimney?

If there are cracks in the brick work or air leaks about the flue connections, cold air will be forced in by the outside pressure of the atmosphere, chilling the gases and reducing the effective push up the chimney. If the breeching and connecting flues are not properly covered, heat will be lost by radiation and the cooling of the gases will affect the draft. Therefore, if you have draft troubles, calk the air leaks and apply insulation.

In a perfect chimney, the temperatures at the top and the bottom of the stack would be the same. A brick is a porous article. Drop a dry brick into a pail of water and watch the air bubbles. A brick chimney presents a relatively large area of air inhaling surface. A steel chimney will "absorb" less air than one of brick, but it will radiate more heat, so that it is about a standoff between brick and steel.

The tendency of the hot gases to rise in the chimney is opposed by the frictional resistance of the chimney. The interior surfaces of the stack should be smooth and, if draft troubles are experienced, the chimney should be swept periodically to remove soot by means of ropes let down from the top of the chimney. Soot is a serious impediment to draft, especially if it is allowed to accumulate upon the tubes and heating surfaces of the boiler. A round stack will oppose less frictional resistance than a square one, because for the same sectional area less surface is exposed to retard the movement of the gases.

Whatever the draft impairment may be, due to leaking and sooted chimneys, the chances are that you will find more potent agencies of impairment in and about the boilers and furnaces. In order to find the causes of draft reduction attributable to the boiler and furnace and measure the effects of these causes, a flue gas analyzer, a draft gage and a torch or tallow candle are necessary. If cold air is bad in the chimney because it impairs draft, it is doubly bad in the boiler or furnace, because it impairs efficiency even more than it impairs draft.

CO_2 Analysis and Loss

The quantity of excess air (air taken in addition to that actually employed in the processes of combustion) may be accurately determined by a flue gas analyzer. The percentage of free oxygen in the gases exactly fixes the percentage of excess air. The excess may be figured from the percentage of CO_2 close enough for practical purposes.

If the analyzer declares that there is an excess of air flowing through the passes of the boiler, search for air leaks in the boiler setting should be instituted with torch or candle. Wherever the flame draws in, there is a leak. Plug it.

When you know that the leaks are all stopped, try the analyzer again. If it still reports excess air, you have too much draft. You must either check the boiler damper or thicken the fuel on the grates. There is a relation between the draft that you should use and the thickness at which the fuel should be carried on the grates. You must find that relation before you can find the conditions that will produce the highest efficiency. I have doubled the effective furnace draft by stopping air leaks. This resulted in an increase of both efficiency and capacity. Where there was too little draft before the leaks were stopped, there was too much draft after stopping them and it was necessary to throttle the chimney with the boiler damper.

When carbon, coal, is properly burned in the boiler furnace, the resulting product of the combustion, CO_2, carbon dioxide is an approximate measure both of the air used and the total air taken. The following table, which is based upon a pure carbon fuel, may be taken as applying in a general way to all fuels in which carbon predominates, viz.: wood, oil, etc. It may not exactly apply to any of them, but the figures will serve as a good yard stick of fuel loss. The average boiler plant wastes about a quarter of its fuel and seriously impairs its draft because it doses its furnace, its boiler and its chimney with excess air. Now, what difference does it make whether the actual loss is 25 per cent or 24¼ per cent? In either case, it is way too much and it must be reduced at once to negligible proportions. Hence, instead of offering many tables, each applying to its own fuel, I offer but one table, which, while not absolutely correct for any fuel in common use, is approximately correct for all fuels.

Per Cent. CO_2	Per Cent. Air Excess	Per Cent. Preventable Fuel Loss
15	38	0
14	47.8	1
13	59.2	2
12	72.5	3
11	88.1	4
10	107	6
9	130	8
8	158.7	11
7	195.7	14
6	245	18
5	314	24
4	417	33
3	590	48
2	935	78
1	1970	*

*Note—The loss becomes total at about 1.1 per cent CO_2, the volume of excess air then flowing through the furnace being so great that it would be impossible to raise the water in the boiler to the boiling point.

The average steam power plant is run on the "hit or miss" or the "catch as catch can" plan. If we analyze the flue gases of this average plant we shall find about 5 per cent CO_2, and on reference to the table we discover that this indicates about 314 per cent excess air,—100 cu. ft. of air taken into the furnace for a use-

ful result and 314 cu. ft. of useless cold air passed over the heating surfaces of the boiler. This increases the fuel consumption by chilling the gases from which the boiler must derive its heat energy. It impairs the draft by giving the chimney excess baggage to carry.

What the Chimney Lifts

We are told that it requires 11½ lb. of air to burn a pound of coal, or around 23,000 lb. for each short ton of coal. The draft must raise this weight to the top of the chimney and, in addition, it must raise the combustible portions of your coal, for the carbon of the coal combines with the oxygen of the air to form the CO_2 of the flue gases. The total weight that the draft must raise is therefore around 25,000 lb. for each ton of coal consumed.

Now, suppose that the flue gases show 5 per cent CO_2, which in all probability is about what they do show. This means that, added to the weight of 25,000 lb. which the chimney must carry, there is an excess ballast of "nigger heads" weighing 72,220 lb. Under such circumstances, the chimney would be doing work enough to carry 3 plants like yours at full capacity and with maximum economy. And yet the owner of such an overworked and uselessly worked chimney finds fault with it. He spends a lot of money for more boilers and more chimneys with the result that his fuel bills go up instead of down, because he has to buy still more coal to heat still more air.

The only thing that draft knows is to burn fuel, and if you have too much draft after the new chimney has been built, or after the air leaks in the old one have been stopped, you must curb this draft as you would curb a nervous horse. You are presumed to know the draft that should be applied to your fires,—the draft that will carry your load and produce the highest percentage of CO_2 without CO.

Draft Gage to the Rescue

You are presumed to furnish a draft gage for the information of your fireman so that he will know whether he is or is not using the draft that he ought to employ.

Excess draft causes you to waste fuel in several ways. It increases the rate at which you burn the coal without a commensurate increase in the rate of water evaporation. The heat from some of the extra coal that you burn is nullified by some of the extra air that is drawn in by the excess draft. The velocity of the gases is increased and the boiler has less time in which to absorb the heat units. The stack temperatures are higher. You lose at both ends and the middle.

A proper draft gage is an important boiler room appliance. It measures the actual draft used, but it cannot tell you the draft that you ought to use. It is like the scales that the druggist employs. These tell him the weights of the drugs he is measuring out, but they do not write prescriptions. In order to interpret drafts properly the gas analyzer must be employed.

Engineers as a rule persist in connecting their draft gases with the uptakes of their boiler furnaces. In this case, as in many others, the common practice is the wrong practice. Suppose you wish to know the water pressure in the supply pipes of your residence. Where do you measure that water pressure? Do you measure the pressure at the pumping station of the water company where the pressure originates, or do you measure it at the faucet in your kitchen where the pressure is expressed? The rate at which you burn your fuel in the furnace depends upon the rate at which you apply air to it, and this rate, as far as a draft gage can measure it, is fixed by the draft in the furnace. The place to measure drafts, accordingly, is the place where the draft is applied. Of course, if you burn the coal in the uptake of your boiler instead of in the boiler furnace, it is another matter.

It must be remembered that the draft gage does not measure gas flow or gas velocities. It merely measures differences in pressure,—between the pressure of the atmosphere on the outside of the furnace and the something less than atmospheric pressure on the inside of the furnace. Under normal conditions, viz., when the fires are clean and of known and uniform thickness, when the fire doors are closed and the ash pit doors open, the draft gage may tell us something about gas velocities. Now, suppose we close the ash pit doors. What happens? The draft, as indicated by the gage, will be increased; but the movement of the gases through the furnace and boiler will be decreased. There may be no movement whatever. On the other hand, if we open the furnace door, air will rush in and move with considerable velocity through the furnace and the boiler. But the gage will show that there is less "draft,"—less difference in pressure—than before the doors were opened. Velocity may accordingly be directly proportional or inversely proportional to the draft as indicated by a differential gage.

If you will do the square thing by your chimney and give it a show—forcing it to perform useful work only—you will find that most of your draft trouble has disappeared, and that the large expense that you have been dreading incident to a new chimney or a higher one, may be avoided. Now, having decided to give the chimney a fair show, why not be a good fellow also with your boilers? Do you know that some of your boilers get more than their share of the draft provided by the chimney and that others get less than their share of it? This isn't fair. You should determine exactly how much draft each furnace should be given for the best results. This draft, as I have stated, is the draft that will produce the highest percentage of CO_2 without combustible CO and carry the load. By proper adjustment of the boiler dampers you can give this draft to each boiler furnace. This will make your boilers pull together like properly driven horses. Your coal bills will be lower. You will have one combustion problem instead of many of them and you will experience less trouble with the smoke inspector. I have known 8 boilers to do the work that 10 were doing before, after draft equalization. And this was accomplished with a straight saving of the coal that had been burned under the 2 boilers.

Draft gages are of great assistance to the fireman. They enable him to give each boiler furnace the exact draft that it should have—the standard draft for the plant, whatever it may be. They enable him to spot the fire that is getting in bad condition. The gage will show an increased draft when the fires are becoming

dirty. It will show a decreased draft when the fires are becoming too thin or when they are burning full of cracks and holes. The gage, when properly connected, will show the draft loss between the uptake and the boiler furnace. If the loss is less than normal, it may be inferred that the baffling has burned out or has been broken down. If it is more than normal, it may be inferred that there are soot accumulations upon the tubes or that there are slag and ash accumulations upon the baffling and brick work of the setting. These things interfere with draft by increasing friction. They interfere with the efficiency and capacity of the boiler by opposing resistance to the passage of heat energy from the gases to the water in the boiler. They make the chimney work harder to give the required draft to the furnace. And all of the things that I have mentioned come home to roost in the plant manager's office. He will find them in his coal bill if he looks for them.

Gas Engine Horsepower

METHODS OF CALCULATING HORSEPOWER OF GAS ENGINES WHEN KIND OF GAS IS GIVEN. BY GEORGE W. MUENCH

HARDLY a week passes without some magazine containing a question from someone wanting to know how to figure the horsepower of his gas engine. The question is usually answered by solving the problem by some approximate, or as we say mathematically, empirical formula. This solves the problem for the inquirer; but suppose he is later confronted by a similar problem, can he solve it this way again? Does he understand the formula well enough to handle it and rely on his own figures? The idea of the following article is to give the gas engine operator and student a clear idea in simple language what the underlying principles are that we use in power calculations, and how we use them.

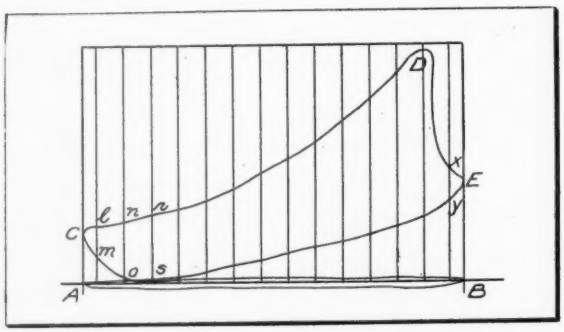


DIAGRAM FROM GAS ENGINE USED IN CALCULATION

First of all, what is work, and what is the unit of work? Work is really the spending of energy toward a definite accomplishment, regardless of how we do it or how long it takes us to do it. The amount of energy necessary to raise 1 lb. 1 ft. we use as a basis of all work calculations, and this unit we call the foot-pound. Remember, we have not yet considered any definite time.

As soon as we consider the time involved in performing a certain amount of work, we can figure power. The unit of power is the horsepower, and has for its value the performance of 33,000 ft.-lb. of work in one minute. For example, raising 33,000 lb. 1 ft., or 33 lb. 1000 ft., or 550 lb. 60 ft., etc., in one minute, is 1 hp.

Now, before we attempt to calculate the power of an engine, let us solve a few simple problems to demonstrate further the method of handling these most important units. For instance, what work is required to lift a 250-lb. piston a distance of 33 in., regardless of friction. $33 \div 12 = 2.75$ ft. $2.75 \times 250 = 687.5$ ft.-lb., the work required. Now, suppose it were required to find the power if above work had been performed in 0.02 min.

$687.5 \div 0.02 = 34{,}375$ ft.-lb. per min.

$34{,}375 \div 33{,}000 = 1.04$ hp.

When speaking of the horsepower of an engine, we should say to which horsepower we are referring. The indicated horsepower (i.hp.) is the power actually developed inside the cylinder of the engine. The brake horsepower (b.hp.), as ordinarily used, is the actual load delivered by the engine. The difference between the i.hp. and b.hp. is the friction, and may be put into formula shape thus: i.hp. — b.hp. = Friction hp.

The absolutely correct formula for figuring the i.hp. of a gas engine is as follows:

$$\frac{PEAL}{33{,}000} = \text{i.hp.}$$

P = Average working pressure in lb. per sq. in. on the piston during the cycle.

E = The number of explosions, or power strokes per minute.

A = Area of the piston end in sq. in.

L = Length of the stroke in ft.

For 4-cycle, single-acting engines at full load, E is half the number of r.p.m., and for 2-cycle engines E is the same as the r.p.m. If the engine has hit-and-miss governor and is not fully loaded, the explosions per minute must be counted. The result obtained from above formula must be multiplied by the number of cylinders when figuring the indicated horsepower of a multicylinder engine.

This formula can be easily explained in detail and this may help to get a better working knowledge of it. P represents the mean effective pressure on every square inch of the end of the piston during the power stroke. So the product of P times A is the total pressure on the piston in pounds. But this total pressure acts through a distance L, or the length of the stroke in feet. Multiplying PA by L, the result will be foot-pounds, and represents the amount of work done during each power stroke. But every minute we get E power strokes, so that by multiplying the above result by E, the answer will be foot-pounds per minute; however, since 1 hp. is 33,000 ft.-lb. per minute, we get the horsepower of the engine by dividing the above work in foot-pounds per minute by 33,000.

The difficulty with this formula lies in finding the value for P. The only absolute way to find it is by means of an indicator on the engine, and calculating the mean effective pressure from the indicator card obtained. There are methods for approximating the mean effective pressure from the compression pressure; but these are not ordinarily satisfactory, and when making a test of any value the engine should always be indicated.

Problem: What is the i.hp. of a 2-cylinder, 4-cycle gas engine, whose bore is 8 in., stroke 10 in., and speed 280 r.p.m.? The mean effective pressure as figured from an indicator card is 69 lb.

$$P = 69 \text{ lb.} \quad E = \frac{280}{2} = 140.$$

$A = 3.1416 \times (\text{radius})^2 = 3.1416 \times (4)^2 = 50.26 +$ sq. in.

$$L \text{ (in ft.)} = \frac{10}{12} = 0.83+.$$

Substituting in the formula,

$$\text{i.hp.} = \frac{69 \times 140 \times 50.26 \times 0.83}{33{,}000} = 12.21 \text{ hp. per cylinder.}$$

i.hp. of the engine $= 2 \times 12.21 = 24.42$ hp.

The above method is the one that should always be used when very accurate results are wanted. For ordinary use, however, we use approximate formulas, as we do not know the value of the mean effective pressure. The approximate formulas must be used with care and judgment, as we cannot use the same one for all the various fuels. In the following:

D = diameter of cylinder in inches.
L = length of stroke in inches.
N = r.p.m.
C = constant, depending on the fuel.

In each formula the resulting horsepower is per cylinder and must therefore be multiplied by the number of cylinders to get the power of the whole engine.

$$\text{b.hp.} = \frac{D^2LN}{C}$$

For gasoline, C = 15,000.
For natural gas, C = 15,400.
For anthracite producer gas, C = 19,000.
For bituminous producer gas, C = 17,500.
For kerosene, C = 16,000.

Problem: What is the horsepower of a 4-cycle, 2-cylinder 11 by 12-in. engine with a speed of 300 r.p.m., when using a bituminous producer gas for fuel?

Substituting in formula given above for bituminous producer gas,

$$\text{b.hp.} = \frac{(11)^2 \times 12 \times 300}{17{,}500} = 24.89 \text{ b.hp. per cylinder.}$$

b.hp. of engine $= 2 \times 24.89 = 49.78$.

This method is intended to give the load the engine will carry at the speed it is running. But if we have an indicator and can get the m.e.p., we can use the absolute formula to calculate the i.hp., and knowing the load (b.hp.), we have sufficient data to figure the efficiency at which the engine is operating.

The efficiency of any machine is always the ratio of the output to the input, or expressed as a formula:

Efficiency = output ÷ input, or,

Efficiency = b.hp. ÷ i.hp. From this it can be seen that the efficiency is always less than one, and is usually expressed in per cent.

Problem: A single cylinder, 4-cycle, 5 by 9-in. engine has a speed of 400 r.p.m. During a test the load was 5.25 b.hp., and the m.e.p., as figuring from an indicator card, was 70 lb. Find the i.hp., the friction loss, and the efficiency.

Substituting in the i.hp. formula,

$$\text{i.hp.} = \frac{70 \times 200 \times 19.63 \times .75}{33{,}000} = 6.24 \text{ i.hp.}$$

Friction loss = 6.24 − 5.25 = 0.99 hp.

Efficiency = 5.25 ÷ 6.24 = 0.841 or 84.1 per cent.

An engine using a weak gas for fuel and high compression will run at a lower mechanical efficiency than one using a rich gas and lower compression. Under good conditions, the following mechanical efficiencies are fair average values. Up to 25 hp. the efficiency is about 75 per cent for 4-cycle engines and about 68 per cent for 2-cycle engines; from 25 to 500 hp. the efficiencies are about 80 per cent for 4-cycle and 65 per cent for 2-cycle; above 500 hp. about 85 per cent for 4-cycle and 65 per cent for 2-cycle.

The engineer who wants to know from day to day what his engine is doing can greatly lessen the amount of work required to calculate the i.hp. by figuring the engine constant. The absolute formula has several quantities that will always be constant for a given engine. These quantities are the area of the cylinder and the length of the stroke. By multiplying the area in square inches by the length of the stroke in feet and dividing by 33,000, the result will be the engine constant. Having indicated the engine, and obtained the m.e.p., and having taken the speed of the engine, its i.hp. will be the engine constant × the m.e.p. × the explosions per minute. In case of multicylinder engines, the engine constant can be further simplified by multiplying constant already obtained by the number of cylinders.

Problem: Determine the engine constant for a 11 by 12-in., 2-cylinder gas engine.

$(11)^2 \times .7854 = 95.03$ sq. in. = area of cylinder.

Length of stroke = 1 ft.

$$\text{Constant} = \frac{95.03 \times 1 \times 2}{33{,}000} = 0.005{,}76.$$

Problem: Above engine, when pulling a certain load at 308 r.p.m., has a m.e.p. of 69 lb. Find the i.hp.

i.hp. $= 0.005{,}76 \times 69 \times 154 = 61.2$ i.hp.

The engineer can further simplify the calculations, and save time and errors, by making up a table of constants for his engine. For example, by multiplying above constant by all integral values between 50 and 120, the results will be constants for all m.e.p. values within those limits for that engine. Having such a table of constants, it is only necessary to determine the m.e.p., refer to the table, and multiply the corresponding constant by the speed of the engine.

Now, having considered various methods for calculating the horsepower, and having especially taken up in detail the absolute method, there still remains to be

shown a method for getting the m.e.p. from an indicator card. No attempt will be made in this article to interpret the indicator card shown in the diagram. It is a card actually taken on an engine and serves to show the method of obtaining the m.e.p.

Divide the length AB into a number, say 14, equal parts, laying off half a part at A, half a part at B, and 13 other parts in between; the more parts, the more accurate will be the results. Now erect perpendicular lines to the atmospheric line AB at the points of division, cutting the diagram as shown. Add together the lengths of these lines intercepted between the lower line C_0E, and the upper line CDE. The first length would be lm; the next lengths are no, rs, etc., finishing with xy. Now, divide the sum of these lengths by the number of divisions, in this case 14. This gives the average height in inches. Multiply value by the scale of the indicator spring used, and the resulting product is the m.e.p. In this particular card the average height is 0.73 in., and scale of spring is 80. Therefore, the m.e.p. $= 80 \times 0.73 = 58.4$ lb. per sq. in. Knowing the dimensions and speed of the engine, and load at the time the card was taken, the complete data are available for figuring the i.hp. and the mechanical efficiency.

Steam Transmission

DESIGN OF PIPING TO SECURE CONSTANT QUALITY STEAM AT VARIOUS LOSSES IN PRESSURE AND RADIATION CONSTANTS. BY ARTHUR O. GATES

IN THE design of steam piping of any considerable length, 2 things must be taken into consideration—pressure drop and radiation. In figuring the efficiency of a steam transmission, most engineers and writers allow that there is some relation between pressure drop and radiation, but have calculated them as separate losses to be deducted from the energy supplied at the beginning of the piping system. In some cases calculations have been made to get the lowest possible total loss due to the 2 factors in the expectation of getting maximum efficiency. In other cases the losses have been calculated and considered against interest on the investment, etc., the more expensive pipe and covering showing the least heat lost.

The writer proposes to show that the 2 factors, pressure drop due to friction in the pipe and radiation loss are so inter-related that the effect of one upon the other must be taken into account, that within limits the smaller steam line is the more efficient; as a practical result of the calculations following, certain diagrams (see Practical Reference Tables) are submitted which enable one to calculate pipe sizes and capacities for the most favorable condition, that of the steam quality being kept constant at all points in the steam line by the effect of the friction upon the condensation due to radiation.

For our purposes there is plenty of checked and time-tested data available, so that experimental proof is not altogether necessary to show the reasonableness of these calculations. For the pressure drop in steam lines we have the well-known formula of Babcock,

$$P = \frac{0.000{,}132\, W^2 L \left(1 + \frac{3.6}{d}\right)}{y\, d^5}$$

in which P is the pressure drop in pounds per square inch between the 2 points in the pipe line considered; W is the weight in pounds of steam flowing per minute; L is the length of the pipe in feet; y is the mean density of the steam in pounds per cubic foot; and d is the inside diameter of the pipe in inches.

As used in calculating pipe size for a definite condition, pipe sizes are assumed and pressure drops determined, the pipe giving the most suitable drop in the judgment of the designer being used, cost being balanced qualitatively against the probable bad effects of the pressure drop. This I believe to be the most general method where any attempt is made to use the scientific data available.

After the pipe size has been decided upon, the radiation losses may be calculated by means of another equally well-known formula,

$$R = \frac{V\, t\, A}{60} = \frac{V\, t\, L\, \pi\, d}{60 \times 12}$$

in which R is the total radiation loss in B.t.u. per minute; V is the unit radiation loss, in B.t.u. per hour per square foot of pipe surface per degree F. difference in temperature between the steam and surrounding air; t is the difference in temperature degrees F. between the steam in the pipe and the air; A is the area of the pipe in square feet; L is the length of pipe in feet; and d is the inside diameter of the pipe in inches.

Now, what is the effect of these 2 losses upon each other? First, what ways can energy be lost from our steam line? Only by leakage, which we expect to be nothing in a well constructed line, and by radiation through the pipe and its covering. The pressure drop takes no heat energy out of our piping system, so that we can say that the only way in which heat is actually lost is through radiation. Any friction within the pipe producing the drop in pressure gives back the energy to the steam in the form of increased quality of superheat, a condition generally considered conducive to higher steam economy, rather than lower. I know of no tests proving this point either way, so that it seems fair to consider the efficiency of our units the same as if they were operating under boiler steam conditions. The only way in which pressure drop could be considered to produce a loss might be in the capacity of our units but a later cutoff is possible on nearly all steam engines, and a more open throttle possible on steam turbines, so that with the bettered condition of the steam this capacity loss would be of little moment.

If the pressure drop tends to add heat to the steam, and thus increase its quality, while the radiation through the pipe and covering carries off heat from the steam, the 2 factors tend to neutralize each other, so far as the moisture in the steam is concerned. If we can balance the radiation loss in B.t.u. by the increased B.t.u. added

as reheat, due to friction, the quality of the steam will remain constant, and it is this condition of constant quality which the writer considers the most rational basis for steam-pipe design.

Between steam pressure limits of 50 lb. and 200 lb. gage, and with drops in pressure that would be considered practical, say, 10 to 15 per cent, an examination of the steam tables shows that the product of gage pressure (14.7 lb. atmosphere) by the difference in total heat of the steam for 1 lb. drop, is practically constant and equal to 15. Then, within the limits specified, the B.t.u. given up per pound weight per pound drop equals 15 divided by g, the gage pressure. Then, when W pounds flow with a drop in pressure of P pounds, the total amount of heat given back as reheat due to friction, per minute, will be:

$$D = \frac{15\,P\,W}{g}$$

Substituting the value of P from Babcock's formula and equating the heat given back D, against the radiation loss R, we have:

$$\frac{15 \times 0.000{,}132\,W^3\,L\left(1+\frac{3.6}{d}\right)}{g\,y\,d^5} = \frac{V\,t\,L\,\pi\,d}{60 \times 12}$$

from which expression, if we call W_h the weight of steam flowing per hour, we have:

$$W_h = 60\sqrt[3]{\frac{g\,y\,V\,t\,d^7}{0.454\,(d+3.6)}}$$

It will be noted that this expression is independent of the length of the steam line.

Assuming the temperature of the air surrounding the steam pipe at 85 to 90 deg. F., the weights of steam for different pipe sizes and radiation factors, lines have been drawn in the diagrams submitted, through points of equal weight of steam. For these weights and pipe sizes, the pressure drops per 100 ft. of pipe have been calculated by Babcock's formula, and the results incorporated in the diagram. Where the pipe sizes are selected on a different basis than that of constant quality, the pressure drops can still be determined at the intersection of the weight of steam and the diameter lines.

Probably 20 lb. drop in pressure is all that the diagrams should be used for, or until within the limits of another diagram. The values of the radiation factor V should be taken only between the limits of 3 B.t.u., the value generally taken for bare pipe, and 0.3 B.t.u., the value for about the most efficient pipe covering.

Checking these diagrams against piping used in practice, one finds that they give values 2 in. and over less than the sizes one finds installed. In case of some large steam turbines, the difference is not very great, the condition under which steam turbines operate being that of continuous flow of steam, to which these diagrams are adapted. Practically all steam lines at present installed are based upon steam engine practice to a greater or less extent, the intermittent demands of the engine cylinder requiring a larger steam line than if the flow were constant. In case this diagram is used for steam engines, consideration must be given to the size of the receiver at the engine throttle, in order that there shall not be too large a variation in pressure. In steam engine practice it has been customary to use steam velocities between 6000 and 8000 ft. a minute, which is considerably below those our diagrams will give, and the effect of this increased velocity must be considered and provided for.

As present practice is to use larger diameters than those here given, I would suggest that an increase of 2 in. in size of pipe over those given will conform fairly well to practice and cause no undue criticism of sizes, but at the same time, I trust these diagrams will be used by designers, and any results checking or showing the limitations will be published.

These diagrams have been laid out upon logarithmic paper, because the lines cross each other at angles greater than could be obtained by the use of ordinary co-ordinate paper, and with less confusion. The fact that these "curves" are straight lines made them easier to plot when the most satisfactory arrangement was decided upon.

In explanation of the diagrams, the horizontal co-ordinates are lines of equal pipe diameter, D, vertical co-ordinates are lines of equal unit radiation loss, V, the nearly horizontal lines sloping downward to the right are lines of equal steam flow, W_h, under the condition of constant quality, the lines rather steeply inclined downward to the left are lines of equal pressure drop, P. The steam flow lines connect the pipe diameter lines with the radiation loss lines, and also connect the pipe diameter lines with the pressure drop lines.

Suppose we have a power plant to build, in which we have decided to use 2 steam turbines having a maximum rating of 5000 kw. each, using steam at 150 lb. gage, the water rate for maximum power being 18 lb. per electrical kw.-hr., the steam-driven auxiliaries requiring 10 per cent additional steam. Assuming between the boilers and the 2 turbines a single steam line 200 ft. long, covered with a high-grade covering like 85 per cent magnesia with a unit radiation loss of 0.3 B.t.u., what diameter of pipe will give us steam at the throttles equal in quality to that at the boiler and without any drainage losses from steam separator?

The 2 turbines will require per hour, $2 \times 5000 \times 18$, equal to 180,000 lb. of steam per hour, and the auxiliaries will require an additional 18,000 lb., a total of 198,000, say, 200,000 lb. of steam per hour. Following up the 0.3 B.t.u. line to its intersection with the steam flow line 200, we get a point on what would be the horizontal line of a 12¾-in. pipe. Say we use a 13-in. pipe, the pressure drop would be found at the intersection of the 200 steam flow line and the 13-in. diameter line, which point we find lies on a pressure drop line of 1½ lb. drop per hundred feet, which means a total drop in 200 ft. of 3 lb., making the pressure at the throttles at maximum load 147 lb. If we decide to use a 14-in. pipe, the drop per hundred feet is less than 1 lb., giving a throttle pressure a little over 148 lb., but requiring a pipe covering which would permit of but 0.16 B.t.u. unit radiation loss. The difference between this unit loss and that actually afforded by the covering used, would show up as condensation.

Another example: Suppose we had some steam engines installed using steam at 125 lb. pressure, and were obliged to abandon the boilers (for age), and wished to install new boilers 1200 ft. away, what size

pipe line should be used, and what pressure should the new boilers carry? These engines have a total capacity of about 1300 hp., and together with auxiliaries require for maximum loads 30,000 lb. of dry steam per hour at 125 lb. pressure, and the pipe covering we wish to use has a unit radiation loss of 0.5 B.t.u. Following up the vertical line from 0.5 B.t.u., we intersect the 30 steam flow line at a point on what would be the line of 4¾-in. pipe. Selecting a 5-in. size, would give us a 5-lb. drop per 100 ft., or 60 lb. for the 1200 ft., indicating that the new boilers should be designed for 185 lb. working pressure. In case we try using 6-in. pipe, the total pressure drop would be 24 lb., requiring a boiler design for 150 lb., but the steam would not be dry unless an extremely efficient covering were used, one having a unit radiation loss of about 0.12 B.t.u.

No account is here taken of the friction and radiation of fittings, turns and valves, the friction usually being taken as equivalent to a length of so many diameters of the pipe, while the radiation will be equivalent to a somewhat less length. This is a thing upon which the designer should use his judgment. The flanges of such valves are frequently bare, and likewise the whole valve in other cases, with radiation consequently almost equal to the reheat.

The use of steam lines designed in accordance with the principles set forth here does not eliminate the steam separator for use with engines, but requires a receiver separator, larger perhaps than it has been customary to install. It might become necessary to install a separator in lines to steam turbines to take care of the condensation at partial loads, aside from its use as a protective device. Every case should be decided upon its merits by the designer.

The designer will find that the calculated values for pipe diameters are lower than in practice, by about 2 in., as has already been stated. Caution will make him increase his sizes to be in accord with practice, yet it is hoped that there will be some who will work as close as possible to the values determined by these diagrams and that they will make the results known.

International Engineering Congress of 1915

UNDER the auspices of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Society of Naval Architects and Marine Engineers, there will be convened at the Panama-Pacific International Exposition, in 1915, an International Engineering Congress.

Engineers in all parts of the world have signified their intention of attending and the delegation from Great Britain promises to be large in point of numbers and great in distinction.

The presidents and secretaries of the 5 organizations named above, together with 18 other members, constitute the official body which will assemble and conduct the congress. Colonel George W. Goethals, chief engineer of the Isthmian Canal Committee, has consented to act as Honorary President of the Congress, and will be in attendance in San Francisco when the celebration is held commemorating the completion of the greatest engineering achievement in all history. The Vice Presidents of the Congress will be selected from the most distinguished engineers of all the nations and, with the President, will form a body of men of the highest standing in the world of engineering.

The week of September 20-25, 1915, will be the time of the sessions of the International Congress, and the proceedings of the meetings will be preserved in permanent book form. These volumes will contain the papers contributed to the Congress by eminent engineers and will embrace in their scope every line of engineering activity, giving the latest word of authority in the field of engineering.

Naturally the Exposition, celebrating as it does the completion of the Panama Canal, appeals with particular force to engineers—to those whose science made the work possible and to one of whom, Colonel Goethals, is being given great honor throughout the world for the success achieved under his skilled direction. As the greatest feat known to their profession, the digging of the canal and the formal recognition of its completed success attract the especial and enthusiastic attention of engineers, for which reason the Exposition management expects in San Francisco, during the latter part of September, 1915, the largest number of engineers ever assembled in a national or international congress.

The executive offices of the congress are in the Foxcroft Building, San Francisco, Cal., where the following officers of the committee are located:

W. F. Durand, chairman; W. A. Cattell, secretary-treasurer; E. J. Dupuy, executive secretary. The following are the chairmen of the subcommittees: C. F. Rand, Participation; W. F. Durand, Executive; W. G. Dodd, Finance; A. M. Hunt, Papers; W. A. Cattell, Publicity; E. H. Benjamin, Local Affairs.

A tentative schedule of general sessions has been formulated and the following sections will be considered:

1. The Panama Canal. 2. Waterways and Irrigation. 3. Railways. 4. Municipal Engineering. 5. Materials of Engineering Construction. 6. Mechanical Engineering. 7. Electrical Engineering. 8. Mining Engineering. 9. Naval Architecture and Marine Engineering. 10. Military Engineering. 11. Miscellaneous.

Each of these sections will hold independent sessions during the congress. Such joint sessions as may be deemed advisable will also be called. On account of the convention of the International Congress of Electrical Engineers just prior to the International Engineering Congress, the activity of the latter in the field of electrical engineering assigned to Section 7, will be limited to consideration of the points of contact between electrical engineering and other engineering phenomena and work.

THE NEW ADDITION to the central generating station of the Toledo Railways and Light Co., of 16,500 hp., has been placed in operation and is working well. The completion of this addition gives the company an opportunity to take on many additional power contracts which could not be handled because of lack of available current. The construction of the high tension transmission belt line around Toledo will be started next spring.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Practical Electrical Engineering

COMPARISON OF ELECTRIC AND MAGNETIC CIRCUITS; CALCULATION OF MAGNETIC CIRCUITS FOR DIRECT-CURRENT GENERATORS AND MOTORS. BY NORMAN G. MEADE

IN every electric generator and motor, the path through which the magnetic flux travels, including the metal and air, is called the magnetic circuit and is subject to laws similar to those governing the electric circuit. The calculation of a magnetic circuit, however, is a more complicated problem than that of the electric circuit, but the operation is much simplified by treating the magnetic circuit in the same manner as an electric circuit and applying the principle of Ohm's law. It is, however, the principle of Ohm's law only that is applied and not the actual electrical quantities.

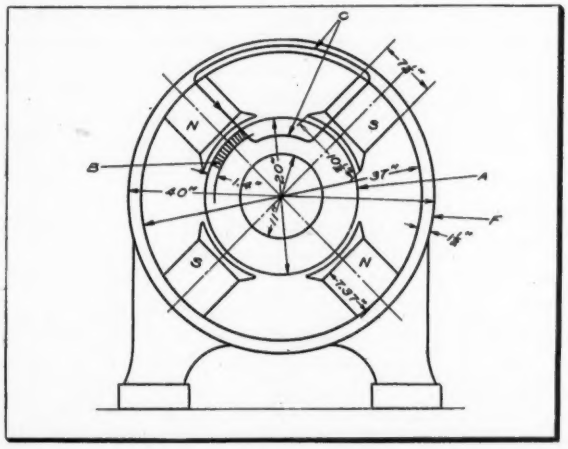


FIG. 1. DIAGRAM OF FRAME AND ARMATURE OF GENERATOR

In the magnetic circuit we have the magnetomotive force which corresponds to electromotive force in the electric circuit. Magnetomotive force may be described as that which produces magnetism; in generators and motors, it is the action of the field windings. To make the analogy between the electric and the magnetic circuit clearer, magnetomotive force may be considered as that which drives the magnetic flux through the magnetic circuit against a magnetic resistance called reluctance.

The total magnetic flux or lines of force can be compared to current in the electric circuit and is found by dividing the magnetomotive force by the reluctance. Expressed as a formula:

$$\text{Magnetic flux} = \frac{\text{Magnetomotive force}}{\text{Reluctance}},$$

which corresponds to Ohm's law,

$$\text{Current} = \frac{\text{Electromotive force}}{\text{Resistance}}.$$

Reluctance of any magnetic circuit depends upon the length of the circuit, the sectional area of the circuit and the permeability of the substance which forms the circuit. Permeability in magnetic circuits corresponds to conductivity in electric circuits.

Reluctance increases directly with the length of the magnetic circuit, is inversely proportional to the cross-sectional area and decreases with the increase in permeability. As in electric circuits governed by Ohm's law, the formula for determining magnetic flux can be transposed to find the magnetomotive force required, thus: Magnetomotive force = magnetic flux × reluctance. There are several magnetic circuits in a multipolar machine as shown in the 4-pole diagram, Fig. 1. Here, A is the armature and F is the field frame; the pole pieces are indicated by N, S, N, S. One magnetic circuit is indicated by C; its path is downward through one north pole, across the air gap into the armature, through the core, across the air gap again into the adjacent south pole, returning to the north pole through the field frame. The armature slots are shown at B and the area and depth of the teeth have to be considered when calculating the magnetic circuit.

As the flux when leaving a north pole divides, half returning to a south pole on one side and half to a

F = Magnetic flux
B = Magnetic density or lines of force per sq.in. of iron or steel
H = Magnetizing force or magnetic density in air per sq.in.
A = Sectional area in sq.in.
m = Permeability
R = Reluctance
f = Magnetomotive force
l = Average length of magnetic circuit
IT = Ampere turns

$B = \frac{F}{A}$ (I) $\quad IT = 0.313Hl$ (VI)

$F = B \times A$ (II) $\quad H = \frac{3.192\,IT}{l}$ (VII)

$m = \frac{B}{H}$ (III) $\quad IT = 0.313FR$ (VIII)

$F = \frac{f}{R}$ (IV) $\quad F = \frac{0.313 \times IT}{R}$ (IX)

$R = \frac{l}{Am}$ (V)

FIG. 2. FORMULAS FOR COMPUTATIONS ON MAGNETIC CIRCUITS

south pole on the other side, we may divide each pole by an imaginary line as indicated by the dotted lines in Fig. 1, then one-half of a north and an adjacent south pole, the yoke from center to center of adjacent poles, the armature core corresponding to pole pitch, and half of 2 air gaps form one magnetic circuit and the solid line indicates its mean length.

It is a general rule that where 2 magnetic circuits pass in parallel through any part of the frame, that part is to be correspondingly subdivided parallel with the direction of the magnetic lines, and the mean length of the magnetic circuit, then, is given by the center line through a part of the frame, thus apportioned to one circuit. In the machine illustrated, 2 parallel circuits

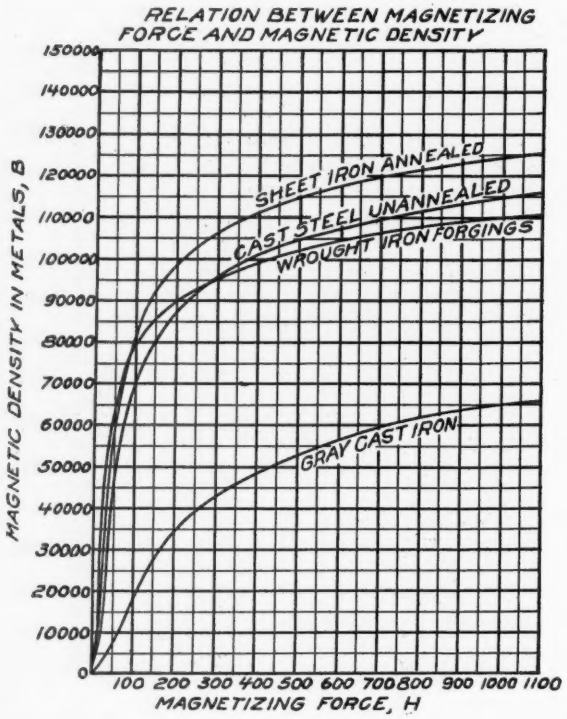


FIG. 3. MAGNETIZATION CURVES FOR VARIOUS MATERIALS

pass through each of the magnet poles; the average line of force passes through the cores at a distance from their edges equal to one-quarter of their width.

Calculating Dimensions of Magnetic Circuit

In Table 1, the principal dimensions of a 100-kw., direct-current generator are given, from which the length and cross-section of each part of a magnetic circuit may be calculated. It is customary to figure the winding required per pole. From each pole the flux branches in 2 directions into the core of the armature, therefore the equivalent magnetic flux in the armature must be considered as half that in each pole piece.

We first determine the radial depth of the armature laminations below the teeth, that is, instead of taking 20 in. as the external diameter we use 20 — 2.8 (twice the depth of slots) = 17.2 in. Radial depth of laminations = $\frac{17.2 - 11}{2}$ = 3.1 in. Magnetic cross-section of armature = (Radial depth × total thickness of laminations measured parallel to shaft) = (3.1 × 6) = 18.6 sq. in. Then 160 × 5.54, the length of armature magnetic circuit per pole, gives 886 ampere turns. In the teeth, the density is 127,000, and this being above the curve for sheet iron, the a.t. per inch are estimated at 390; 390 × 1.4 = 546 ampere turns. For the pole pieces, the density 96,500 gives from the wrought iron curve, 110 a.t. per inch, and 110 × 7.37 = 810 ampere turns.

The density of the yoke is 79,000 lines per square inch; from the curves we find for annealed cast steel the ampere turns per inch of length for this density is approximately 45. Length of yoke per pole = 15.12, then 15.12 × 45 = 680 ampere turns.

For determining the air gap ampere turns per pole, we use formula VI, Fig. 2, H being the same as B for air since $M = 1$. Therefore, the air gap ampere-turns = 0.313 × 49,200 × 0.235 = 3620 ampere turns. The sum of these will be, 886 + 546 + 810 + 680 + 3620 = 6542 ampere turns per pole, which agrees within 2.5 per cent with the former result, as close as can be expected in such computations.

When determining the magnetic length of the armature, it must be remembered that the winding on each pole sends the flux half way towards the next pole, and to avoid plotting the actual half length of the average line of force, it is general practice to substitute the mean periphery of the armature laminations divided by 2 × number of poles.

Mean diameter of armature

$$\frac{17.2 + 11}{2} = 14.1 \text{ in.}$$

Magnetic length per pole =

$$\frac{14.1 \times 3.1416}{2 \times 4} = 5.54 \text{ in.}$$

The armature teeth are, of course, narrower at the bottom than at the top and as there is some contraction near the top caused by the wedge notches, it is a reasonable assumption to accept the working width of the tooth to be located midway in its length or 0.7 in. from the periphery.

The circumference of the armature at this point is 20 — (2 × 0.7) × 3.1416 = 58.43 in. There are 80 slots, therefore the slot pitch at the given circumference is 58.43 ÷ 80 = 0.73 in. Width of tooth = slot pitch — slot width = 0.73 — 0.35 = 0.38. Multiplying by net core length, the cross section area of a tooth is 0.38 × 6 = 2.28 sq. in. Number of teeth per pole = length of pole arc ÷ slot pitch at armature periphery; 3.1416 × 20 ÷ 80 = 0.785; 10.5 ÷ 0.785 = 13.38. Magnetic area of teeth per pole = 13.38 × 2.28 = 30.5 sq. in.

Adding 10 per cent for fringe or spreading of the lines as they pass from pole to armature, magnetic area of teeth = 30.5 + 3.05 = 33.55 sq. in. for entire flux per pole or half that = 16.78 sq. in. per magnetic circuit.

Magnetic area of air gap = area of pole face + 10 per cent allowance for fringe = 10.5 × 7.5 × 1.10 = 86.62 sq. in. for a pole, and half that = 43.31 sq. in. per magnetic circuit.

Area of pole piece $= 7.5^2 \times 3.1416 \div 4 = 44.17$ sq. in., and half that $= 22.09$ sq. in. per magnetic circuit.

Owing to the fact that the pole shoe has so small a radial depth, its reluctance represents but a very small reluctance, therefore it may be neglected in all ordinary cases.

TABLE 1.

Dimensions of Component Parts of a 100-kw., 250-volt, d.c. Generator Operating at 1000 r.p.m., 4 poles
(All dimensions in inches)

Armature

	In.
External diameter	20
Internal diameter	11
Gross length of laminations	8
Net length of laminations	6
Number of slots	80
Depth of slots	1.4
Width of slots	0.35

Frame

External diameter	40
Internal diameter	37
Thickness of yoke	1.5
Width of yoke	18
Pole piece diameter	7.5
Length of pole piece radially	7.37
Width of pole face parallel to shaft	7.5
Length of pole arc	10.5
Pole pitch	16
Pole arc divided by pole pitch	0.66
Radial length of air gap	0.235

Magnetic Dimensions

Magnetic area, armature	18.6	sq. in.
" length per pole, armature	5.54	in.
" area teeth per pole	16.78	sq. in.
" length teeth	1.4	in.
" area air gap	43.31	sq. in.
" length air gap	0.235	in.
" area pole piece	22.09	sq. in.
" length pole piece	7.37	in.
" area yoke	27	sq. in.
" length yoke per pole	15.12	in.

Magnetic Densities

Flux per pole, required	4,275,000	lines
Flux per magnetic circuit	2,137,500	"
Armature core density	114,200	" per sq. in.
Armature teeth density	127,000	" " " "
Air gap density	49,200	" " " "
Pole piece density	96,500	" " " "
Yoke density	79,000	" " " "

Permeability

Armature core	225
Armature teeth	150
Air gap	1
Pole piece	275
Yoke	540

We obtain the magnetic area and length of the yoke in the same manner as with the armature core.

Magnetic section $= \left(\frac{40-37}{2}\right) \times 18 = 1.5 \times 18 = 27$ sq. in.

Magnetic length $= \left(\frac{40+37}{2}\right) \times 3.1416 \div (2 \times 4) = 15.12$ in.

To determine the magnetic density in any part of the circuit, we divide the flux in each magnetic circuit, which is half the flux per pole as given in Table 1, by the area of the part of the circuit under consideration. Flux per circuit as determined from voltage calculations must be $4{,}275{,}000 \div 2 = 2{,}137{,}500$ lines. For the armature core $2{,}137{,}500 \div 18.6 = 114{,}200$ lines per square inch; armature tooth density is $2{,}137{,}500 \div 16.78 = 127{,}000$ lines per square inch, and so on.

MAGNETIC CIRCUIT SYMBOLS AND FORMULAS

FIGURE 2 gives the symbols and formulas used in the calculation of magnetic circuits and before taking up the calculation of reluctance and ampere turns, it may be well to study them briefly. Formula (I) states that for any magnetic circuit or part of a circuit, B, the magnetic density or lines of force per square inch of iron or steel is equal to F, the magnetic flux divided by A, the sectional area in square inches. If $F = 150{,}000$ and $A = 10$, then $B = \frac{150{,}000}{10} = 15{,}000$. Formula (II) states that magnetic flux is equal to the product of B, the magnetic density or lines of force per square inch of iron or steel and A, the area in square inches. It is a transposition of (I). Formula (IX) is also used for determining F and states that F = the constant $0.313 \times$ ampere turns, I T, divided by the reluctance. If $I\,T = 500$ and $R = 0.05$, we have $F = \frac{0.313 \times 500}{0.05} = 3130$. In formula (III) we find that permeability M = magnetic density in iron or steel divided by magnetic density in air, both using square-inch measurements. Permeability, as a matter of fact, has been determined by exhaustive tests by large electric companies and curves have been plotted therefrom upon which we mainly depend.

Referring to Fig. 3, the curves show the relation between magnetizing force, H, or magnetic density in air per square inch and the magnetic density in iron or steel per square inch. We see that a magnetizing force, H, of 500 will produce a magnetic density of 115,000 lines per square inch in annealed sheet iron, as the vertical line above 500 H, intersects the sheet-iron curve on the horizontal line corresponding to $B = 115{,}000$. Now, as $M = \frac{B}{H}$ the permeability in this problem $= \frac{115{,}000}{500} = 230$. Permeability curves are plotted in Fig. 4, together with ampere-turn curves, which will be used later. The balance of the formulas given in Fig. 2, will be practically applied in this and succeeding articles.

RELUCTANCE OF GENERATOR MAGNETIC CIRCUITS

FORMULA V states that reluctance R = the length of the magnetic circuit divided by the product of its area times the permeability. From Fig. 4 let us determine

the permeability for the different magnetic circuits of the generator.

We see from Table 1 that the armature core density is 114,200 lines per square inch. From 114,000, in the vertical column of figures representing magnetic density,

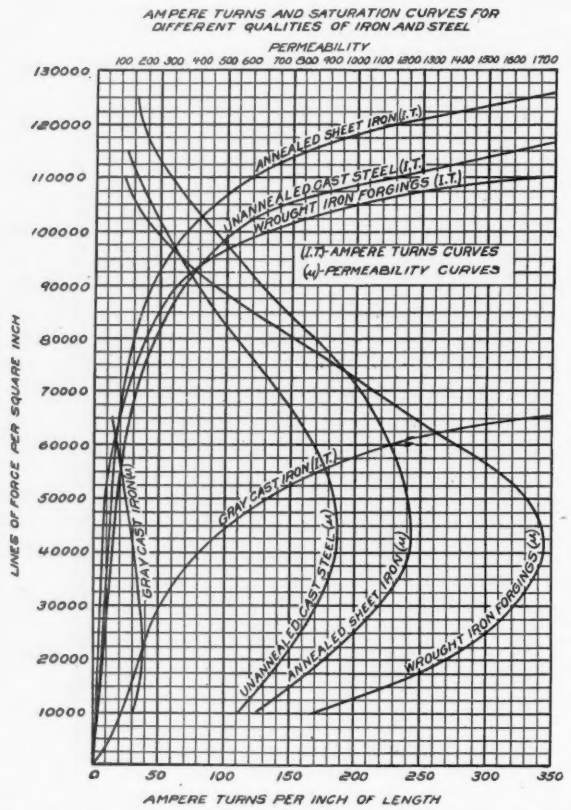


FIG. 4. PERMEABILITY AND AMPERE TURN CURVES FOR CALCULATING MAGNETIC CIRCUITS

follow the horizontal line to the right until it intersects the sheet-iron permeability curve, then directly above read 225, the permeability. Density in armature teeth (at working width of teeth), is given as 127,000; but as the sheet-iron curve only reaches a density of 125,000, we will estimate the permeability of the teeth as 150. The permeability of air is always 1, so that the air-gap permeability will be 1. The pole pieces are wrought-iron forgings and for a density of 96,500 we get from the curves a permeability of 275. The yoke we assume to be made from annealed cast steel and find from the curves that at a density of 79,000 lines the permeability is approximately 540. We will now determine the reluctance of each part of the magnetic circuits by formula (V), Fig. 2. The operations are shown in Fig. 5.

Calculating Ampere Turns

From equation VIII, Table 1, we now have $I\,T = 0.313 \times 2{,}137{,}500 \times 0.009{,}56 = 6380$ ampere turns.

It is possible, by the use of the ampere-turn curves of Fig. 4 to get this result without determining permeability and reluctance, as those curves give the ampere turns per inch in length for different materials with different flux densities. The armature core has a density of 114,200 lines per square inch and the material is annealed sheet iron. From 114,200 in the column representing lines of force per square inch, follow horizontally to the right to the intersection of the annealed sheet-iron ampere-turn curve, then at the bottom immediately underneath read 160, the number of turns per inch of length.

Pole Winding

For preliminary calculations, let us assume the outside diameter of the field coil to be 10.5 in. and its length 5.375 in., which gives an outside cylindrical surface of 177 sq. in. and the mean length of one turn of wire 2.35 ft., found as follows: Diameter of magnet core $= 7.5$ in., outside diameter of coil 10.5. $\frac{10.5 + 7.5}{2}$ $= 9$ in. $= 0.75$ ft. mean diameter; the circumference for this is 2.35 ft.

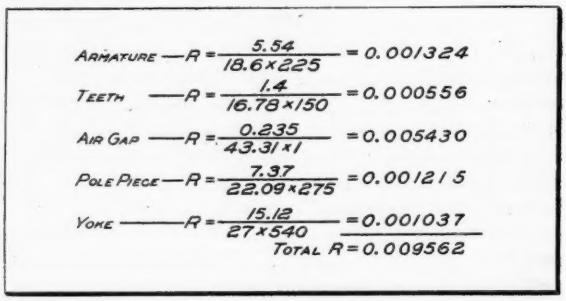


FIG. 5. COMPUTATIONS OF RELUCTANCE FOR PARTS OF MAGNETIC CIRCUIT

To find the area of the wire in circular mils for the field winding, the following formula is used:

$$A = \frac{12 \times l \times I\,T}{E}$$; in which A = sectional area of wire in circular mils; l = mean length of one turn in feet; I T = ampere turns and E = e.m.f. The generator voltage is 250, so we will estimate 50 volts per pole, allowing 50 volts for rheostat regulation. Ampere turns per pole = say 6500.

$$A = \frac{12 \times 2.35 \times 6500}{50} = 3660 \text{ circular mils.}$$

This is about half way between No. 14 and No. 15 B. & S. wire gage, hence we would use half of each. If we allow 1 per cent loss in fields, the energy will be $100 \times 0.01 = 1$ kw., and the current would be $1000 \div 250 = 4$ amperes. The resistance per coil would be volts $\div$ current $= 50 \div 4 = 12.5$ ohms. From the wire table, resistance of No. 14 is 2.7 ohms per 1000 ft. and for No. 15, 3.3 ohms per 1000 ft., hence for half of each in series the resistance would be a mean of these or $(2.7 + 3.3) \div 2 = 3$ ohms per 1000 ft. and the length required would be $12.5 \div 3 = 4.02$ thousand or 4020 ft., which at 2.35 ft. per turn makes 1710 turns.

Tables for cotton-covered wire give 200 turns per square inch of section of coil for No. 14 wire and 275

turns per square inch for No. 15. The area of coil as estimated is 1.5×7 in., allowing something for heads, or 10.5 sq. in. $1710 \div 2 = 855$ turns each of Nos. 14 and 15; $855 \div 200 = 4.28$ sq. in. for the No. 14, and $855 \div 275 = 3.1$ sq. in. for the No. 15 or $4.28 + 3.1 = 7.38$ sq. in. total as against 10.5 sq. in. available.

It is evident that the coils may be made smaller, using smaller wire, so consider all No. 15 wire. $1710 \div 275 = 6.22$ sq. in., which for 7 in. long gives $6.22 \div 7 = 0.89$ in. thick, or, say, 1 in. with tape wrappings. Mean diameter $= 7.5 + 1 = 8.5$ in. and length of 1 turn $= 26.7$ in. or 2.22 ft. $1710 \times 2.22 = 3800$ ft. per coil, which at 3.3 ohms per 1000 ft. gives $3.3 \times 3.80 = 12.5$ ohms per coil. $50 \div 12.5 = 4$ amperes, which is the current desired.

For a coil 1 in. thick, the outside diameter will be $7.5 + 2 = 9.5$ in., and the circumference 29.8 in. This times 7 in., the length, gives $29.8 \times 7 = 208$ sq. in. Watts in the coil are $I^2 R = 4^2 \times 12 = 192$ watts. This divided by 208 gives 0.926 watt to be radiated per square inch. To keep the temperature within safe limits, the radiation should be not over 1 watt per sq. in., so we are well within the limit.

We would, therefore, wind 3800 ft. of No. 15 single cotton-covered wire into each coil, making 1710 turns, with inside diameter of 7⅝ in. and outside diameter of 9½ in.; length of coil, 7 in.; tape the coil to hold it in shape, and connect the 4 coils in series to form the field winding.

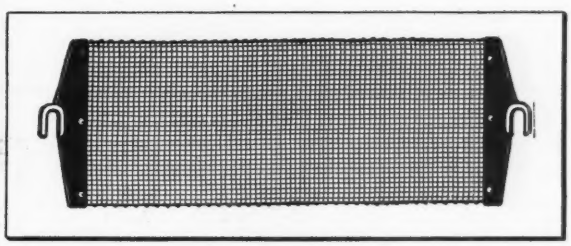
The rheostat should have a capacity of 5 amperes, continuous, and a resistance of 15 ohms to allow some margin for regulation with speed variations and for differences in material. It is always best to have a safe excess margin of exciting force to take care of unforeseen conditions, and the number of turns per coil should be made greater rather than less than the calculations call for, and it might be wise to use 4000 ft. of wire per coil, giving 1800 turns per coil, a margin of 5 per cent.

Woven Wire and Cord Resistance

New Foreign Type of Grid Reduces Weight and Increases Durability of Rheostat

It may be interesting to refer to a new type of resistance which is being produced by C. Schneiwindt of Neuenrade, Westphalia, Germany, and which is shown in the illustration herewith. These woven wire grids are made up of Constantan resistance wire woven in parallel with excelsior wire, and are fitted with lugs complete for fixing. The fixing lugs are not affected in any way when subjected to vibrations, and they form an excellent substitute in place of cast-iron grids. This is a valuable feature as the older form of grid is the cause of continual annoyance through breakages. These woven wire grids are practically indestructible. The great advantage of woven wire grids is that they are compact and are considerably lighter in weight than cast-iron grids and manufacturing firms will probably find the adoption of woven wire of considerable benefit in place of the usual cast-iron construction. These grids are usually made in 3 standards of width, namely, 4, 5 and 6-in., and can be made to any specified length, but for special requirements it is, of course, possible to produce widths of any required dimensions.

In another form these resistance bands are woven for momentary heavy current carrying capacity and are specially adapted for use in oil resistances. When immersed in oil, the bands are capable of carrying approximately 50 per cent additional current. The methods of mounting these resistance bands are numerous. One of the simplest and most practical methods of mounting, however, is by stringing the bands in a zigzag fashion over vulcanized fiber tubes, which are attached to a wooden frame by means of steel bolts. When the bands are thus assembled, the complete resistance is totally immersed in oil. With wire of 0.1 mm. diameter and capable of carrying 0.2 amperes, a band measuring 1 yd. by 4 in. has a resistance of 6750 ohms, while a



WOVEN WIRE TYPE OF RESISTANCE GRID

band of similar width and length, with wire of 1.4 mm. diameter, can carry 12 amp. as a maximum and has a resistance of 6 ohms.

Closely allied to these grids is a cord resistance which is made by the same firm to meet the special requirements of numerous customers, and this form of resistance material is much in demand. It is made either as a wire or flat strip wound on asbestos cord and is supplied in thicknesses ranging from 1.5 mm. to 5 mm., and also as a wire or flat strip woven with asbestos strings, which can be supplied in any desired width ranging from 5 mm. upward. The wire employed is Constantan, which is similar to Eureka or Ferry wire; but for heating purposes Nichrome or Platinum wire can be used. These cord resistances are most suitable for heating elements for electric hot-plates, kettles, flat irons, electric ovens, etc. The resistances are practically unbreakable; they are jointless, and quickly and easily mounted. It is claimed that they are unaffected by continual heating and cooling and can be run at a dull red heat without damage. They are a most compact form of resistance material and there is no doubt that the wire resistance grids and cord resistance form a most important advance in electrical apparatus construction.

Power privileges on portions of the Sarco and Ossipee Rivers in Maine, for the generation of electricity for lighting and power in the towns of Hiram and Baldwin, are to be developed, according to J. Merrill Lord, who appears as the instigator and promoter. A corporation has been formed under the name of the Hiram and Baldwin Water, Light and Power Co. It is understood that work on the dam and power house will start in the near future, as the options secured are all short ones, none being over 1 yr. and some for 6 months.

Electrical Correspondence

Mica-Cutting Tool

IN THE power department of a factory in which I work, one of those peculiar troubles caused by high mica confronted me.

There were several mica-cutting tools described in Practical Engineer, but none suited me. Some were tedious and with others the work proceeded too slowly to be satisfactory. I designed a mica cutter on the principle of the chisel and which is to be used like one. No guide of any sort is necessary.

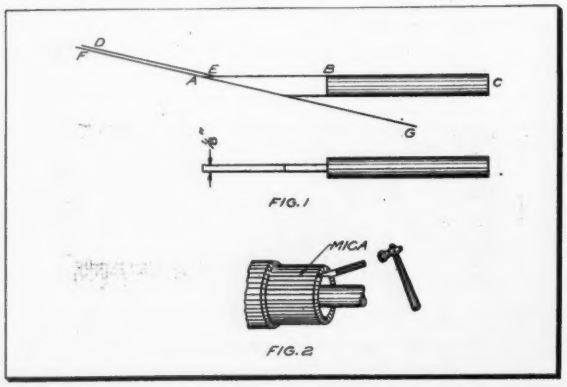


FIG. 1. CHISEL FORM OF MICA-CUTTING TOOL
FIG. 2. METHOD OF USING MICA-CUTTING TOOL

The end, AB, should be flattened out to the thickness of the mica, in this case ⅛ in. The line, DE, represents the surface of the mica; FAG, the cutting line; the distance between these 2 lines is the depth of the cutting. The end, A, should be sharpened in order to do good work. Figure 2 shows the manner in which the tool is used.

This tool is highly satisfactory when one gets accustomed to using it correctly. ALVIN CROFT.

Voltage of Dynamo

A WIRE is cutting lines of force at the rate of 100,000,000 per sec., there is induced in it an e.m.f. of one volt. What is the e.m.f. of a dynamo armature having 50 coils of 5 loops each and making 600 r.p.m.? Each wire cuts 2,000,000 lines of force twice in a revolution.

J. R. B.

A. You start with the fact that 100,000,000 lines of force cut per second gives 1 volt e.m.f. The problem then is to find the total number of lines cut per second by the wire in the dynamo armature. As the kind of connection of your dynamo is not specified, we have to assume that all wires are connected in series, so that the e.m.f.'s are added together. One wire cuts 2,000,000 lines in one revolution, in 600 it will cut 600 times that, or 1,200,000,000. Then each loop will have 2 wires or 5 loops would have 10 wires, and 50 coils would have 500 wires, which would give 500 times the number of lines cut by 1 wire, or 600,000,000,000 lines cut per second. Dividing this by 100,000,000 gives 6000 volts as the electromotive force generated.

Control System for Panama Canal Locks

(CONTINUED FROM PAGE 139)

to the receivers by means of bevel gears. When the miniature gates are completely opened, they are covered by shields to give the effect of the gates folding back into recesses in the lock walls.

For the chain fender, the position indicator transmitter is driven by the shaft which operates the limit switch that controls the stroke of the piston. The indication on the board is given by a small aluminum chain, which, like the large chain, is raised and lowered, each end operating independently, the large chain being lowered to the bottom of the lock and the small chain into a slot on the control board. The ends of the miniature chain are fastened to semaphore arms which are connected to segmental gears meshing with the driving gears on the receiver machines. As the receiver rotors turn, the chain is either lifted or lowered, the position of the large chain from the bottom of the lock being indicated by the angle of the semaphore arms.

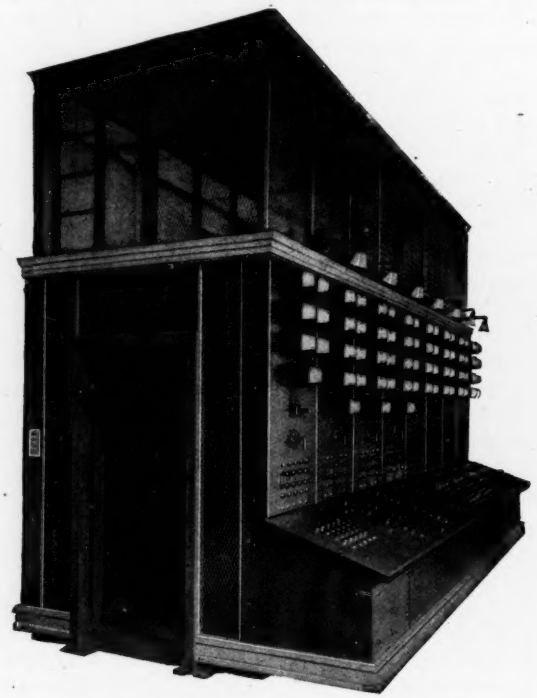


FIG. 8. INSTRUMENT AND CONTROL BENCHBOARD FOR GATUN HYDRO-ELECTRIC STATION WITH GALLERY FOR FIELD RHEOSTATS

As the rising stem valves occur in pairs, their position indicator machines occur in pairs also. The transmitter rotor is driven by a shaft and gearing similar to that described for the mitering gates. Each indicator is similar to a small elevator, a car being used to indicate the position of the valve gate. Both front and back of the shaft are fitted with opal glass marked with black lines for the ¼, ½ and ¾ positions. A small aluminum cage moves up and down in each compartment. A drum for operating the cord which raises and lowers the cage is located underneath the control board and is operated by the receiver through a suitable train of gears. To

make the indications visible from points up and down the control board, the elevator shaft under each car is always illuminated and the portion above is dark.

Water Level Indicators

Specifications covering the water level indication required an accuracy of 1/20 of a foot or 1/10 of 1 per cent in actual water level. In the transmitters and receivers for the machines described previously, the rotors turn less than 180 deg. with an inherent lag of 1½ per cent between transmitter and receiver rotors in this distance, which obviously prevents this arrangement from being employed to give the water level indication.

It was found that if the rotors were revolved 10 complete revolutions, the required accuracy could be obtained, but since this arrangement makes it possible for the rotors to be in synchronism every 180 deg., or in 20 different positions for the entire travel, the indicators would not indicate correctly if for some reason the transmitter rotors were turned more than ½ revolution with the power off. Therefore, the required accuracy was obtained by 2 sets of transmitters and receivers, one set connected to a fine index in which the rotors make 10 complete revolutions and the other set connected to a coarse index operating less than 180 deg.

The fine index is a hollow cylinder carrying a pointer, the length of the cylinder being such that when an aluminum ball representing the coarse index, which can be depended upon for coarse indication, is within the limits of the cylinder, the reading of the fine index is correct within the limits specified. The scales are illuminated by lamps in both base and top caps of the indicator.

For water level indication, wells 36 in. square in the lock walls with communication to the lock by a small opening at the bottom of the well to dampen surges contain a welded steel box float, 30 in. square by 9 in. deep. A non-slipping phosphor bronze belt transmits the movement of the float to a sheave fitted with pins on the transmitter mechanism, the pins registering with holes punched in the belt. The sheave shaft is carried in ball bearings with oil cups for lubrication and drainage cocks at the bottom of the bearings.

The position of the miter forcing machine is not indicated by synchronous indicators, but its open and closed positions are shown by red and green lights and a mechanical indicator on the control board representing the machine.

Control Boards Represent Locks in Miniature

The control boards are of the flat top benchboard type, 32 in. high by 54 in. wide, built in sections, with total lengths as follows: Gatun, 64 ft.; Pedro Miguel, 36 ft.; Miraflores, 52 ft.

Side and center walls of the locks are represented by cast-iron plates and the water in the locks by blue Vermont marble slabs. The outer edge of the board is surrounded by a brass trim rail, and the sides are enclosed with steel plates which can be readily removed for inspection of the board. The control board is supported by a wrought iron framework resting on base castings, which are in turn supported on the operating floor of the control house.

The control switch handles are mounted above the surface of the board and operate through an angle of 90 deg. They are provided with nameplates for the "open," "closed" and "off" positions. The space immediately below the flat top of the control board is occupied by the contact fingers of the control switches, mounted on the operating shaft, synchronous receivers and their cable connections. Connection boards are provided for the cables, which are led up from each side, as are buses for supplying current to the control switches, receivers and the lamps that illuminate the scales of indicators. The receivers, transmitters and lamps are operated at 110 volts, while the control circuits are 220 volts, both using 25-cycle alternating current.

Mechanical Interlocking System

In order to make it necessary for the operator to maneuver the control switch handles always in a certain order, corresponding to a predetermined sequence of operation of the lock machinery, and to prevent the operator in control of one channel from interfering with the machinery under the jurisdiction of the operator controlling the other channel, these control switches are provided with interlocks. The interlocks are in 2 vertical racks under each edge of the board and some distance below, so that they may be inspected and oiled from a floor which is about 7 ft. below the floor on which the switchboard operator stands. The latter floor does not extend across under the board, this space being open so that all parts on the underside of the board are accessible from the floor below.

Vertical shafts operated by connecting rods from the control switch shafts extend downward past the electrical parts for the operation of the interlocks. The interlock system is essentially a bell crank mechanism, connecting the shaft of the control switch through a movable horizontal bar to a vertical operating shaft which can or can not move according to the relative positions of the interlocking bars and dogs. The interlocking rack is a steel frame carrying 5 horizontal members. Upon these and tying them together are vertical steel straps which carry brass runway posts for the vertical and horizontal interlock bars. These posts are riveted to the vertical steel straps, a thin brass plate between posts and straps making the runways non-corrosive. The vertical operating shafts are of square steel turned on the ends and work in brass bearings near top and bottom of the interlocking rack. Forked cranks mounted on the vertical operating shafts move the horizontal interlock bars by means of pivot blocks set over pin blocks riveted to the horizontal bar. The interlock bars and dogs are of special shape hard extruded brass, which section keeps the dogs in line with the axis of the bars when under pressure by being engaged with another dog on a vertical bar. Every control switch uses a horizontal bar from 3 to 50 ft. long.

The interlock system depends mainly on the action of engaging bevel dogs located on horizontal and vertical bars, the movement of a horizontal bar tending to lift a vertical bar by bevels on the dogs. A horizontal bar cannot be moved without raising a vertical bar. Thus if at any time a dog on a horizontal bar rests against the upper end of a dog on a vertical bar, no movement of

the horizontal bar where the dog engages with the vertical bar can take place, and the control handle connected to that particular horizontal bar is locked.

Interlocks prevent the chain fender from being lowered until adjacent mitering gates have been opened, and also prevent the gates being opened until the chain is in the raised position. In this way it is assured that the chain fender will always be in the up position to protect the gate when the gate is closed. To avoid unnecessary complication, each end of the chain is interlocked with the leaf on its side of the lock only, because as a rule both leaves of a gate, as well as both ends of a fender chain, will be opened simultaneously, and further interlocking is unnecessary. After the mitering gates are closed, a miter forcing machine is operated by a control handle and locks the ends of the gates closed. This machine cannot be operated until the gates are closed.

Also the rising stem valves of the side wall, next above or below a miter gate, must be closed while the miter forcing machine is open. As the miter forcing machine cannot be closed until the gates are closed, this means that the valves either above or below the gate must remain closed until the gate itself is closed, thus preventing the operator from creating a current of water around the gates while they are open, or being moved in opening or closing. This interlock is not included on the middle wall valves for the reason that they will be used with the locks on either side and must be free for that purpose.

Either pair of rising stem valves may be opened first, at the choice of the operator, an interlock becoming effective when the first valve of the second pair of duplicates is opened. This is done by a novel arrangement of equalizing levers acting against the ends of the interlock bars, with certain definite amount of lost motion which is taken up on opening the first pair of valves, thus putting the interlocks in operation on the next pair. To illustrate this operation, consider, for example, a side wall culvert at Gatun with its principal rising stem valves at each change of level from one lock to the next. The control of these valves is interlocked so that if the valves are opened at one particular point, the valves a lock length upstream or downstream cannot be opened. Thus the operator is limited to equalizing the water between locks and cannot allow water to flow from the upper lock past the middle lock into the lower lock, which operation, if permitted, might flood the lower lock walls and the machinery chambers in them. The cylindrical valves are interlocked so that if those on one side are opened, those on the other side are locked closed, and the opening of one switch on a side will lock the opposite 10. This prevents careless cross filling between locks, which operation might be combined with the regular method and produce flooding. However, there may be times when it is desirable to employ cross filling to economize in the use of water from Lake Gatun in the dry season. For this reason this interlock is made removable by the use of a Yale lock and key. The key will be placed in the hands of the chief operator.

In the use of the middle wall culvert, the cylindrical valves on one side or the other must be opened before the rising stem valves can be opened, and the rising stem valves must be closed first. This interlock is applied in order to require the operator to control the flow of water by means of the rising stem valves rather than by the cylindrical valves.

In most cases the locks are divided into the 2 unequal parts by the intermediate mitering gates. This arrangement makes it necessary to divide the 10 cylindrical valves into 2 groups of 7 and 3, respectively, for the long and short lengths. A selecting lever is provided for these interlocks and may be set as indicated by a nameplate on the lever to 3, 7 or 10, respectively; whereupon the corresponding valves are subject to that interlock, and the others of the group of 10 are locked closed if 3 or 7 only are to be used. The failure of the operator to make his selection properly in advance will simply cause him the trouble of going back and doing so, as the remaining valves are locked closed. This arrangement permits handling small vessels without causing waste of water due to operating such vessels in the large chambers. If a short vessel were being passed downstream, it would first pass into the chamber having 3 cylindrical valves. The group selective lever would then be placed on the "3" position which would permit the opening of 3 valves above the intermediate gate, but would lock closed the other 7 valves above it. After the vessel had been passed below the gate the handle may be reversed, releasing the lever and locking 3 switches.

There are intermediate rising stem valves in the side walls at each intermediate gate, but no interlocks are applied to those for the reason that they will be used in a more or less irregular manner, and no fixed laws for their operation can be made in advance. Moreover, they control the water only between different sections of the same lock, and there is not the danger from mistakes in operation, which exists in the case of the other valves which control water between lock levels. The same is true of the small auxiliary culvert valves, by means of which the space between the upper guard gate and upper main gate is filled and emptied.

In case a large vessel is to be locked through, the interlocks on the intermediate gates can be made ineffective by the operation of a Yale lock which uncouples a clutch and disconnects the central switch from the operating mechanism. Turning the key removes the interlock and permits the intermediate gates to be thrown open to obtain a 1000-ft. level, and the valves operated independently of these gates.

To obviate the possibility of flooding the locks when valves are in a certain position, diagonal interlocking is introduced between the rising stem valves of the side wall and those of the middle wall a lock length away. This interlocking between valves diagonally across a lock when the cylindrical valves are open is needed to prevent the flow of water from, say, the upper lock by way of a side wall culvert to the middle lock, thence by way of the middle wall culvert to the lower lock, thus allowing an operator, through carelessness, to flood the lower lock walls. If the cylindrical valves of a certain lock are closed, the interlock is not needed on the rising stem valves of that lock; and since such interlock would interfere with the proper use of the valves of its twin lock on the other side of the middle wall, this interlock is automatically removed when all 10

cylindrical valves are closed on the particular lock in question, and is automatically applied again if one or more of the 10 cylindrical valves are opened. Furthermore, the valves of the side wall immediately at the gate which is being moved will be open to equalize water level, and diagonal interlocking will prevent the opening of the middle wall valves a lock length above or below the gate being moved. Each of the 4 valves of such a group has independent control, their control switches being so interlocked that either pair may be opened and left open as guard valves, the interlocks becoming effective when the operator tries to open the first valve of the second pair. In addition to these pairs of valves in parallel, each pair is duplicated at each change of level from one lock to the next.

Special Climatic Requirements

To withstand the humid atmosphere of the Isthmus, every insulated part, such as solenoid, relay, circuit breaker and other coils, was impregnated with non-hygroscopic compounds. All small parts were made either of brass, copper, Monel metal, bronze, or sherardized iron or steel. Mica and treated asbestos lumber were used largely in place of fibre or wood.

All of the lock machinery motors, control panels, centralized control boards, power station generating apparatus, switchboards, transmission line substation equipments, coaling stations, and practically the entire electrical equipment for the wharf terminal cranes and for the extensive permanent repair machine shops were manufactured by the General Electric Company.

Correspondence of An Old Engineer and His Son

The Installment Plan and the Boss Watchers

MY DEAR SON DONALD:—

Your ever welcome letter of several weeks ago was received in due time and, being somewhat under the weather, I wrote you a postal at the time to let you know that we had heard from you.

But my old friend, the rheumatiz, seems to have singled me out specially of late to administer the several things that the flesh is heir to, just to keep me from getting too allfired spry, I guess. That's just about as you will find it all over, no matter where you go.

Just about the time you feel that things are letting up a little and that you are leaning towards easy street, something happens to set you back a little and demonstrate to your entire, but painful, satisfaction that you are just the common kind of clay after all.

That reminds me of old Bill Hoskins, way back East, who had an explanation for every happening that ever happened. He used to say that "just as soon as one gets something laid by for a rainy day, somebody breaks a rib in the umbrella."

I guess that he is about right, too, at that, for while it is hope that keeps our spirits up and urges us all on to do our very best, every once in a while (sometimes twice in a while) we get a little set back just to keep us from getting rich too fast, for if we all got rich and didn't have to work, then we would all be poor and have to go to work again. You see it is a sort of a cycle with a flyball governor on that seems to regulate our standing in this vale of tears and keeps us from speeding up and busting the flywheel.

Just after you started to the Bergville Technical Institute, a young couple moved into the Downs' house, second house from us (I guess you know which one it is) and they had it all doped out just how to go about it to start married life just exactly right. As the new wife used to run over to see mother every little while about how to make biscuit, or sponge cake, or how to get mildew stains out of the tablecloth, she never seemed to tire of telling just how their "plan" was going to work out.

No matter how she started out, she always wound up with finances and this expression, "Harry and I won't have to pinch but one more payday and then we'll be square."

At the end of the first year, this got to be a sort of habit with her, as they were still just one payday behind right along. The installment collector did the trick. About the time that they got the lace curtains paid for, they were worn out. Sometimes they wore out first. Still they were optimistic, which is all right, indeed.

Everything they had was on the installment plan. They were always pinching to make both ends meet,—or rather to keep them from getting too far apart. Finally, they moved away and I never saw them again till about 6 months ago, when mother and I were coming home from church one nice Sunday and we met them out for a stroll. While she didn't say that they would have to pinch just one more payday, yet they were still pinching along—and they looked the part. The bloom had left the pretty face and a wistful look was in her eye. Harry's best suit looked shiny, while his shoes didn't.

There were 3 children which also were a part of the installment plan. They were pinched, too. That was not their fault; that was their misfortune. He was going from one job to another where there seemed to be a better "chancet," as he called it, and never stayed at one place long enough really to become of any use to the firm nor to learn anything worth while for himself.

I asked Harry why he didn't take up night school and see what he could do, but he said he didn't have time and, besides, he wanted to sleep, nights. So, I suppose they are still pinching just one more payday, and always will be.

Now, I suppose, Donny boy, that you want to know what the idea is. Well, it's right here. Few people realize what an enormous struggle it is to break even with this world while we are here, and have the mistaken idea that life is like the rainbow,—the pot of gold is just over there a little way, waiting to be picked up. In a way, there is a pot of gold at the end of the rainbow of life. This is the hope that is held up; but let me say right here, to get that pot of gold, you have got to be on the job right along. As soon as one begins to

get discouraged, it is an easy matter to slip back. It seems to me that I wrote you a letter once on "sand," didn't I?

Did you ever see a person that has lots of time to spare that ever amounted to anything? Not very often, if at all. Whenever you see a man that really is a factor in the day's doings, he formed the habit while young, of getting on the job early and sticking to it. Look around you at the old men who have acquired a competence for their declining years. Many of them are in misery if they cannot be doing something. In looking over the biographies of many of the country's principal men, while you see a few that tried a number of places before they seemed to strike their notch, you will see by a careful analysis that most of them had an aptitude for some one line or kind of work, and when they were young they went at that job, hammer and tongs, early and late, and by self denial, and study,—study, mind you,—they soon learned the job thoroughly and made themselves master of it *and kept the mastery of it.*

I suppose by this time you are beginning to wonder what all this has to do with your engine room and my rheumatiz. Well, I sometimes climb over the fence from the original pathway, and before I know it, I get away so far that I lose the landmarks.

You are still young and I guess that you have a good job, or do you get enough now so you call it a position that pays a salary? You got a good education to start with, or at least I paid out a lot of good money for one, and you started out on your own initiative and got a plain job and have worked up quite a little. You don't know how glad I am that you are getting along so well, but it does a man good to be encouraged. Right here is where many employers and fathers are negligent. In many a factory, you can go on doing your tasks precisely right till judgment day, and that is about all there is to it, but if you happen to miss punching your card once or punch some other fellow's, there will be the largest display of "why" red tape you ever saw. I believe that if it is necessary to censure a man for good and sufficient reasons, there are just as good reasons why he should be encouraged when he does his work right.

Of course, I have to take my little constitutional every day or so, as I have done for the last 50 or 60 yr., after I have taken care of the garden, helped mother with the washing or peeled the potatoes for her, and in my walks it is but natural that I should wind up in an engine room some place, where I can get a whiff of hot oil and talk shop and "reminisce" a little, so as not to get rusty. It seems that an engine room draws me to it just as a brewery draws a Dutchman.

Well, in getting around like this, I frequently see a great many things that are really surprising. One thing that seems to me to be more prevalent than any other, is the little question of keeping the weather eye open for the boss. For instance, over where Martin O'Connor runs there are a number of foreigners working, the kind that they call "guineas" (whatever that is). While the boss is around they really earn a *little* money, but just as soon as his back is turned, or he goes over to look after some part of the work, those shovels cool off pretty fast.

This disease isn't particularly partial to the foreigners. Shirking seems to be in the air these days. How often have I seen machine hands "cutting air," as they call it, making believe that they are doing a hard job, waiting for the whistle to blow. I have seen lots of men actually work harder to kill time than they would have to if they did the job right. But somehow or other it never seems to pay dividends. When the boss suddenly comes in the door and finds a lot of the men jumping to get onto the job again, it doesn't take him long to form his conclusions. Some day they will want a "straw boss" to look after some little job, and do they ever pick out the fellow that is always getting up off a nailkeg when the boss appears suddenly? Not so as to be particularly conspicuous. But they do pick out the bright young fellow who isn't always rolling a cigarette before the whistle blows; one who has been seen a number of times, noons, figuring on the side of a board some problem that has stumped him at night school. The boss soon learns who is improving his opportunities and such a fellow is usually the one to bring home the bacon.

If a man wants the firm to take interest in him, he must first take an interest in the firm's affairs. A man never gets more than he earns till he earns more than he gets. This idea that so many have, "Oh, the company has got lots of money," never got anyone anywhere but outside of the main gate. If one takes an interest in the firm and its affairs and future, he is more apt to receive a few words of encouragement from the boss, and when this is done once it is easier for the boss to do it the second time. After a while the boss begins to notice that this man's work is such that it attracts him on account of its superior qualities,—and some day this young man will be called up into the office and hear something like this:

"Young man, we have been watching you of late" (and he wonders what for, and what he has done to be fired!), "we have been watching you of late and we have decided to" ('Yes, I guess that I get fired,' he says), "we have decided to put you in charge of the west machine shop. Do you think that you can swing it?"

Can he swing it? That is what he has been going to night school 5 yr. for and learning not only how to read blueprints but how to make the drawing. When he gets into the shop, he is pretty apt to see some place where a jig or a template will cut down the cost of manufacture, and (more night work) he makes a sketch and shows it to the super., and it is 10 to 1 that it goes through. The super. begins to take notice of him and before long this man is well along in the race to the top, possibly may be president of the firm. Such things have happened, while the fellow who kept the top of a soap box well polished is still jumping every time the door opens.

Well, Donny, I got so interested in writing that I forgot that I had the rheumatiz and writer's cramp; but as mother says that supper is ready and the biscuit and rhubarb pie smell good, I will close, hoping to hear from you soon.

Mother sends her love and wants to be remembered to Hazel.

Affectionately, your father,
SANDY MACDOUGAL.

Foreign Development In The Power Plant Field

THE WEARING OF STEAM TURBINE VANES; POLE PRESERVATION; LUBRICATING OILS; SILICA IN WATER. BY J. H. BLAKEY

WITH every turbine, the consumption of steam increases with the wearing of the vanes, which becomes more noticeable when the turbine is kept running at its full capacity. At the end of a certain time the wear of the vanes is such that the steam no longer strikes them at the correct angle of incidence; the result is an increased consumption and necessarily a diminished efficiency. The principal factors in the wearing of the vanes are: 1. The quality of the feed water, the influence of which is not always considerable. 2. The degree of superheat, of which the effect is generally greater, the high temperature causing the steam to attack the surface of the vanes, which becomes roughened, in addition to which an increase of temperature of 250 deg. C. may be sufficient to destroy completely vanes of bronze. 3. The material of the vanes; bronze not giving satisfaction, a 5 per cent nickel steel is now being generally used. 4. The style of turbine and its method of construction, milled vanes with reinforced section for attachment to the crown having been found to give the best results.

A thorough drying of the steam before admission is the first condition of good running. The preservation of the vanes is best promoted by bringing the steam to them at reduced speed by means of previous throttling. It is better to run at ½ or, at most, ¾ capacity. Under these conditions a turbine, after 31,000 hr. of running, consumed 18 per cent more steam than at first; whereas, another, similar in every respect but running at full capacity, after 29,700 hr. of running consumed 27 per cent more steam than at the beginning of the test. In a note published by the Revue Industrielle, M. Eric concludes that the consumption of steam increases so quickly that the question of the renewal of the vanes must always be considered after from 20,000 to 25,000 hr. of service.

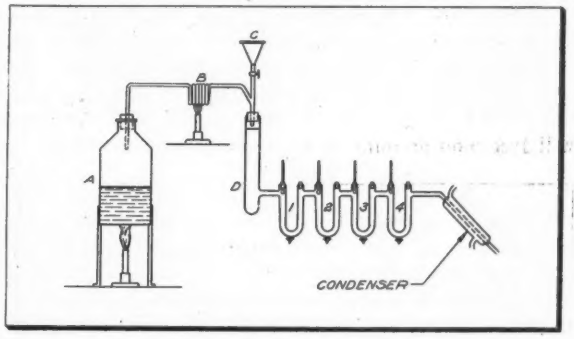
NEW PROCESS FOR PRESERVING WOODEN POSTS

THE PROCESSES now in use for the preservation of wooden posts by impregnation with carbolineum, which is a combination of anthracene oil (from coal tar) and zinc chloride, have been improved upon by a method described by M. Geck in the Electrotechnic Zeitschrift, which has been found to give good results. This method also has the advantage of making possible the treatment of the posts in place. At the base of the post, near the ground level, where decay always begins, 2 holes about ⅜ in. in diameter are drilled radially and at right angles to each other. Into these holes, which have a depth equal to ¾ the thickness of the post, metal tubes are driven. These tubes are connected with a tank containing carbolineum under an air pressure of 3 atmospheres, produced by an air pump. It has been found that by this method ½ lb. of carbolineum can be injected into each hole in about 10 min. If petroleum, which is also a good preservative, is mixed with the carbolineum, it is found that the distribution of the liquid in the interior of the post is made much more uniformly. After the operation, the holes are filled up with wooden plugs.

VOLATILITY OF LUBRICATING OILS

AS SO many of the surfaces which require to be lubricated are at high temperature when the machine or engine is running, and as efficient lubrication depends upon the preservation of a film of oil between the surfaces in contact, the matter of the volatility of lubricating oils is of considerable importance. An oil with a high volatility may be perfectly satisfactory for cold or cool surfaces, yet a test would show it to be absolutely worthless when used on surfaces raised to a high temperature by contact with superheated steam, for instance.

The illustration shows an apparatus for testing the volatility of oils which is used at the laboratory of



APPARATUS FOR TESTING LUBRICATING OILS

L'Association Alsacienne des Proprietaires d'appareils a vapeur, of which the last report contains a memoir on the subject by M. Kamerer. Steam is generated in a flask, A, and conducted to the superheater, B, which may be a coil in the tube heated by a burner. The oil to be tested in C drops onto a fine sieve in the upper part of the tube, D. The purpose of the sieve is to spread the oil and cause it to be thoroughly volatilized by the action of the steam. From the tube, D, the steam and all are conducted to the U tubes, 1, 2, 3, the number of which will be determined by the range of temperature for which it is desired to test the oil. Each of the U tubes is supplied with a drain cock and a thermometer. The total amount of oil passing through the apparatus is carefully weighed, and also the amount condensed in each U tube. The relation of the amount condensed in the first tube to the total amount will give the volatility at that temperature. The relation of the sum of the quantities from the first and second tubes to the total will give the volatility at the temperature of the second tube, and the relation of the sum of the amounts from the first, second and third tubes to the total will give the volatility at the temperature of the third tube, and so on.

Silica in Boiler Feed Water

In the Zeits. des Ver. deutsch Ingen., M. Goldberg, of the Society of German Engineers, writes upon the subject of silica in boiler feed water. He says that waters which are moderately soft and clear, and in every respect suitable for drinking, often contain a considerable amount of silica in solution. When used as feed water for boilers, such waters give rise to dangerous incrustations, which produce serious corrosion on account of the presence of chlorides and nitrates dissolved in the water, whose acids are liberated by the silicic acid at high temperatures. These incrustations are very impermeable, and are rendered still more so by the presence of oil in the feed water. Occasionally they are so serious as to cause the boiler plates to become red hot. The remedy is the addition of a small amount of potassium or soda, which, however, makes necessary a daily cleaning out of the mud in the boiler.

Double-Pipe Ammonia Condensers

Trouble from Freezing, Methods of Draining and Cleaning. By A. G. Solomon

DOUBLE-PIPE ammonia condensers have certain excellent features which recommend them to their users. They are neat in appearance, clean, and can be placed almost anywhere. In a great many instances this last good quality is sorely abused and the condenser is set up in a hot engine room with no air circulation whatever and air is a benefit, if not as necessary as it is to an atmospheric condenser of the single-pipe type. It is not advisable, however, that a double-pipe condenser be placed outside in a climate where the winters are very cold. As all know, it is almost impossible to drain thoroughly this kind of condenser, and the chance of freezing up and bursting is great. Another danger is that some of the inner (water) tubes might be blocked, or so nearly blocked, that the water will freeze on account of the slow circulation.

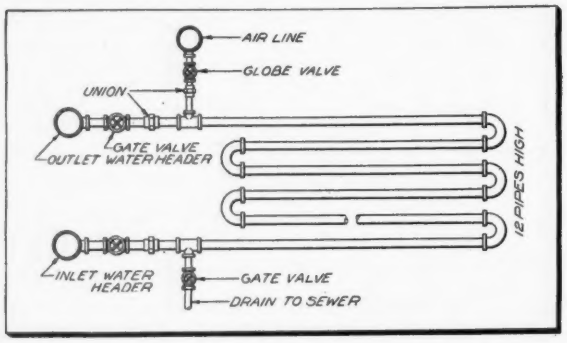


FIG. 1. AIR CONNECTION FOR BLOWING INNER TUBE

An accident of this kind happened and nearly resulted in a big loss of ammonia. The plant had been shut down, as there was no demand for ice owing to the cool weather; instead of attempting to drain the condenser, the pump was kept going, and we naturally thought that the circulation was as it should be. The next morning, after starting the ice machine, the engineer went outside and took his usual walk around the condensers. Of course, there was no ammonia smell, as the leak was in an inner tube. He heard the hissing noise and immediately cut out the coil. The hissing stopped at once, so he knew that there was no use to pump out; he decided that the leak was so big that the ammonia would be all gone before he could change the valves.

Getting some help, the return bends were taken off at one end and the leaking tube located. The tube was replaced with a new one and then the split one was examined. It was found that a piece of pump valve spring had at some time become stuck in the tube and, as time went on, small pieces of plunger packing and bits of wood had nearly made a solid plug. The water had a very slow circulation through this coil and froze, with the resulting split of about 6 in. in the tube. We afterward put a screen in the discharge line of the pump, so I don't think this trouble will occur in that plant again. A screen should be placed in the discharge line of all pumps; I now believe it is just as important as the screen that is nearly always put on the end of a suction line. Valves, springs and plunger packing will get away at times and no one can tell where they will land till the trouble has occurred.

If those condensers are to be drained, about the only sure way is to have an air line connected to each coil and blow them out separately till all the water is expelled.

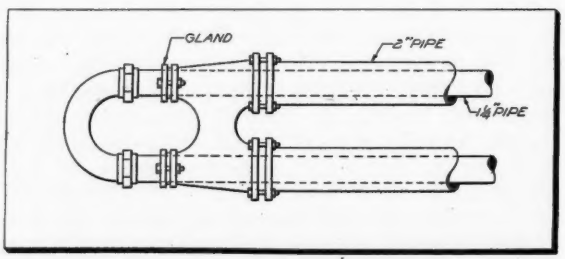


FIG. 2. AMMONIA AND WATER RETURN BENDS

This air connection is useful in another way. No matter how clear the condensing water is, there will always be some sediment left in the tubes. By blowing the coils out occasionally, all this sediment will be removed and I am sure it will surprise some to note the good results. The tubes should be scraped out with a good tube scraper at least once a year, and more often if necessary. It is little work and does not take much time. I had charge of a plant where we used water from shallow wells, and the trouble with sand was a difficult proposition. The tubes had to be scraped once a month without fail. They were not cleaned all in one day, but some every day, and by the time we got over the condenser once it was time to start over again.

When using the double-pipe condenser, a full charge of ammonia is absolutely necessary if results are to be obtained. The gas and liquid space is small and if the

charge is allowed to get low, the ammonia will travel too fast and the expansion valves will get a slug of liquid and then gas will go through for a while. Keep as big a charge as can be properly handled. A small charge is more noticeable with this type of condenser than with the single pipe.

The liquid space can be greatly increased by leaving out the inner tubes of the 2 bottom pipes and still the gas will be condensed as well as before. I have tried this way of operating and found it to work well. Blind flanges will have to be made to blank the openings in the ammonia return bends and they must be made just right to hold the gasket and also put on so there is no danger of blowing off and losing a whole charge. It is not safe to bolt this blind flange to the lugs that hold the gland. The lugs might pull off, owing to the increased strain which will be put on them. Bolts long enough to reach to the 4-bolt flange of the 2-in. outer pipe will be found satisfactory in every way. The sketch will make this plain.

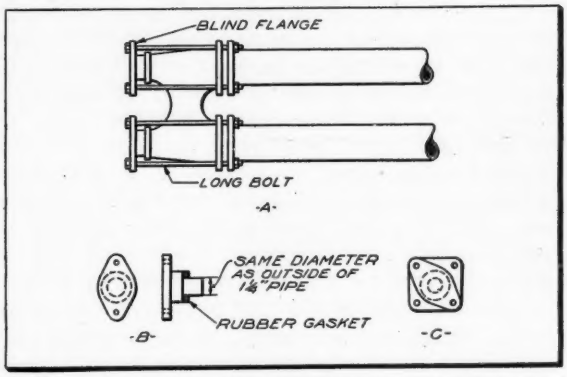


FIG. 3. BLIND FLANGE AND METHOD OF ATTACHING IT TO PIPE

Figure 2 shows ammonia and water return bends with packing gland having 2 bolts holding it in place. Lugs are cast on the ammonia return bend for the bolts.

Figure 3A shows the blind flange in place, with long bolts extending to the 4-bolt flange on the 2-in. pipe. At B are shown 2 views of the blind flange, and the position of the blind flange, as it must be turned to allow bolt holes to come in line, is shown at C.

I tried some other ways of doing this job, but this is the way in which I left it, as it proved satisfactory. Water can be run over the outside of the 2 bottom pipes by putting drip pans underneath, but this is not really necessary. The inlet water header will have to be raised so that the openings will be at the third pipe from the bottom instead of at the bottom pipe.

Purging this style of condenser is not so readily accomplished as with the single pipe. It takes longer for the noncondensible gases to separate and rise to the top. Ammonia will come in small squirts before all the foul gas is blown out.

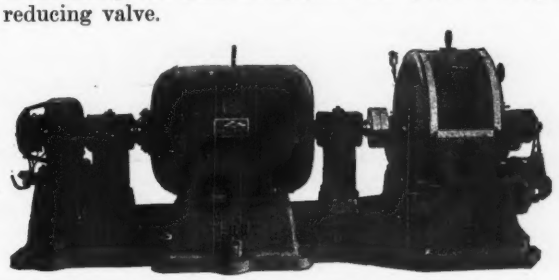
PLANS FOR EXTENSIVE ADDITIONS to the plant of the new Utilities and Public Service Co., formerly the Mt. Carmel Gas & Electric Co., Mt. Carmel, Ill., were discussed recently and will be carried out. The plant will also be enlarged considerably. It was announced that A. R. Manley will be retained as superintendent of the company for the present.

Hospital Power Equipment

TURBO-GENERATORS FURNISH POWER FOR THE ROBERT B. BRIGHAM HOSPITAL

AS one admires the magnificent view of the Metropolitan district from the Robt. B. Brigham Hospital, located on the summit of Parker Hill, Boston, he little realizes that a power plant of sufficient size to supply the entire needs of this large hospital, is anywhere near.

Inside the power house, the equipment consists of 3 B. & W. boilers, each equipped with an automatic stoker; these boilers supply steam to 3 62½-kv.a. Terry turbo-generators. The generators are 3-phase, 60-cycle, 220-volt machines made by the Allis-Chalmers Co. The turbines, noncondensing, deliver their exhaust directly to a Warren Webster vacuum heating system. Whenever in severe weather, the exhaust from the turbines is insufficient, live steam is added to the system through a reducing valve.



TURBO-GENERATOR SET IN ROBERT B. BRIGHAM HOSPITAL PLANT

Communication between the plant and the hospital is through a long tunnel, which runs nearly horizontally from the upper part of the one to the basement of the other. This tunnel is large enough to contain all the necessary heating mains, the mains for the distribution of electrical energy, and provides a passage for the various attendants of the mechanical department. A circular staircase gives access to the tunnel from the turbine room.

The turbo-generators supply current for the laundry and kitchen motors, for the refrigeration apparatus, for the 2 pumps which raise water from the city mains to the pressure tanks which supply water to the entire hospital, for individual motors for special purposes in different parts of the hospital, and for the lighting of the entire set of buildings.

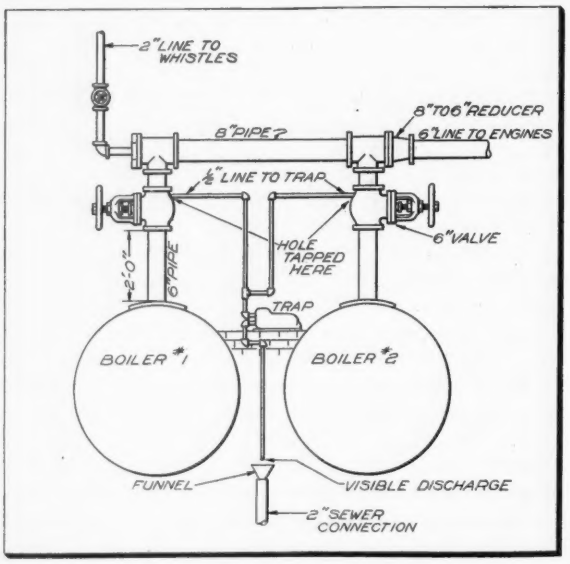
The location of the power plant on this high hill, away from easy communication, made it desirable to do everything possible to insure continuous service in the equipment. The boiler capacity is generous and a spare generating unit has been provided. The Terry turbines are built for severe service, an especial feature being the sturdy motor, which will be uninjured by the passage of heavy slugs of water when starting quickly from a cold condition. One more fact which emphasizes the care taken in the design and location of the power plant, is the location of the stack. In order to eliminate the possibility of disturbing the hospital patients by smoke, this stack was placed some 100 yd. away from the power plant and at a much higher elevation. The foot of the stack is reached by suitable underground ducts from the power house.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Position of Valves on Steam Lines

I HAVE been greatly interested in the discussion of the Indiana law in regard to the location of valves in steam outlets of boilers, by Mr. O'Neill, J. C. Hawkins and others. The accompanying sketch shows how I solved the problem in the plant of which I have charge. Boiler No. 1 is fired 2 weeks, during which time water collected above the stop valve of No. 2 and when No. 2 is fired up and cut in, this water was forced over and through the engines. It also caused the top flange of the stop valve of No. 2 to leak. When No. 2 was in use and No. 1 idle, the whole pipe from the stop valve on No. 1 to the opening of the tee on No. 2, contained water and all joints leaked; when the whistles were blown this water rushed up through them, flooding the roof and, of course, they would not make a sound until the water escaped.



DRIP PIPING FROM BOILER LEADS

When No. 1 was again cut in, a greater amount of water was forced through the engines. By tapping a hole in each valve just above the disk and seat and leading out a ½-in. pipe to a steam trap located on top of the brick work at the rear and between the 2 boilers, the trouble was overcome and the trap has required no attention whatever in the last 2 yr. I first piped the discharge from the trap to the heater, but found that the steam backing up the pipe from the heater caused the trap to remain closed all the time. I then piped the discharge to the sewer and it works fine. There are no valves between the stop valves and the trap, hence it is impossible for anyone to make the scheme inoperative, although repairs to the trap or piping necessarily must be made with both stop valves closed.

JOHN H. LINTON.

I HAVE read with considerable interest the criticism of J. C. Hawkins of my scheme for location of valves on steam outlets of boilers to conform to the laws of the state of Indiana, for it may be inferred from his statement that my article was designed as a defense of the law. My idea was to show a perfectly safe scheme to conform to a law whose defense is solely up to the Indiana legislature.

Mr. Hawkins states: "If these valves were always operated by a careful engineer, there might be little danger, but as a rule this is not the case. Usually the boilers are cut in by the fireman, or sometimes by a coal passer, who may not be careful in opening the valves."

If these statements are true, it is a sad commentary on the engineering profession, for in no power plant operation is more care necessary than in the case of operation of valves for the distribution of steam.

It is just as important to use care in the operation of steam valves as it is to switch properly a 10,000-kw. generator into an electric circuit. In fact, it is generally possible to protect the electrical apparatus from the results of improper switching; but, in most instances, improper handling of steam valves leads to disastrous accidents.

My impression is that in any plant which has an excuse for existence, valves should be handled only by an engineer whose license should be a guarantee of carefulness. Such is certainly the case in any well ordered plant. While not exactly in line with the question, another reason why the engineer should go up on top of the boiler to cut in, is so that he can test the safety valves, which require careful inspection after each period of idleness.

Regarding the destruction of the angle valve, Mr. Hawkins does not state enough concurrent facts for one to be able to determine the cause of the failure. It is hard to see just how it could have been due to water hammer. Offhand, I should say, either the valve was weakly designed or materially faulty, or the piping layout not correct to take up expansion due to temperature changes. Sudden expansion of the pipe due to rapid admission of steam at maximum temperature might not have been properly taken care of in the swing or spring of the pipe, hence the failure of the valve.

A well operated plant of which I know has a layout of valves similar to mine. Although it has been in operation for many years, there never has been such an accident as Mr. Hawkins fears, nor has anyone ever dreamed there would be one. The layout, moreover, was designed to conform to the best practice of its day without any question of legal interference. The emergency valve is opened when the fire is lighted or before; when the steam pressure of the boiler gets within a pound or two of the line pressure, the stop valve is opened. Cutting in is not very dangerous, if done according to proper rule by a competent man; but it is decidedly dangerous even with the best of layouts, if done in a haphazard way by a novice or an ignoramus.

Rather than to repeal the "Indiana Law," it would be better to disqualify an engineer who did not personally attend to the operation of the stop valves.

HAYLETT O'NEILL.

Cooling Tower

ON PAGE 1156 of the December 1 issue, is a request from a reader, asking for information as to what size cooling tower will be necessary to cool 2000 gal. of water per minute, as well as to give him some detailed information as to how to construct such a machine.

A machine to cool 2000 gal. of water a minute from approximately 110 to 80 deg., to be built of the atmospheric type, would prove to be a rather burdensome job to tackle. First off, a tower of this type would take up almost all of the space he has available, and the cost of building this would run into many thousands of dollars.

This brings to the writer's mind a controversy that he had recently with a large company which was in the market for cooling towers. (The writer happens to be connected with a concern whose business it is to manufacture and sell towers.) This company sent out requests for propositions on a tower to cover requirements, and after getting all this information, together with detailed blueprints from each of the companies bidding, decided that a tower was a simple enough thing to build, and so thanked all of the engineering concerns for their kind courtesies in submitting bids and detailed blueprints, and started to erect its own tower.

The writer went up to see this concern after he learned just what they were going to do and tried to convince the executives that they could buy a tower cheaper than they could build one. This sounded unreasonable to the purchasers; they could not be convinced of this fact. The writer, however, arranged for the following: He was to give this concern all the information regarding the building of their home-made atmospheric tower—in fact, doing all the engineering for them. This service was to be absolutely gratis. In exchange for this, they were to keep a detailed report of the cost of their tower, including material, labor and everything in connection with the building of this machinery.

It took a good many months to erect this tower, and when it was finally completed, the cost exceeded the cost of the tower that the writer quoted on by almost 50 per cent. You can now readily appreciate just what this means. In the cost of the building of this home-made tower there were no charges included for the efforts, energies and mental fag that the purchasers went through in this connection.

The experience related above is not the only one that the writer has had in this connection. The fact that large concerns are in the business of building cooling towers, and that they are all successful, is the strongest argument for concerns buying a machine rather than building one themselves.

Another item in this connection, is the fact that when a cooling tower concern accepts an order for a machine, it installs that piece of apparatus under an absolute guarantee to perform certain duties. It is specifically stated in the contract, just how many gallons of water per minute are to be cooled, from what degree to what degree, with atmospheric conditions at such a temperature, and a relative humidity of such and such a per cent. In the event the tower fails to come to this contract guarantee, the purchaser has some sort of a comeback. The machine was installed for certain duty and that duty it must perform. With a home-made tower, there are no such provisions made.

Readers of this article must not misunderstand the attitude that the writer is taking. He is not condemning the capability of the engineer who attempts to build this machinery or any other piece of apparatus that may be in his plant. The writer has seen, and so has every one of you, home-made machines that have given, and are giving, most excellent service and returns, but it is the writer's past experience that prompts him in saying that he feels sure that in 99 cases out of 100, a cooling tower, especially one of such capacity as 2000 gal. per min., should be built by a concern that makes a specialty of this line; in other words, experts.

The writer is doubtful whether the inquirer will be able to get a cooling tower for his service that will not exceed 30 ft. in height. The minimum height of a forced draft tower for this service would be at least 35 ft., while a natural draft, or atmospheric tower would be nearer 80 than 30 ft.

NATHAN OWITZ.

Precipitating Carbonates from Water

IN LOOKING over your January 1 issue, on page 12, is an article on "Water and Its Treatment," and we refer to the ninth paragraph, in which the statement is made that:

"Heating the water to a temperature of 212 deg. drives off carbonic acid on which the holding in solution of the carbonates depends, so that frequently if carbonates form the chief solids in solution, heating to this temperature will be sufficient to throw down the solids in the feed-water heater."

Technically, this statement is true, practically it is misleading. In the first place, carbonic acid is only released for that length of time in which the water is in a state of ebullition and this is a condition which cannot exist in a feed-water heater. The parallel condition to ebullition is the breaking up of the water into small particles on the heater trays, and the time element allowed for this in any heater which has ever been built so far, is so small that the percentage of the carbonate taken from the water by heat alone is not worth while.

We have followed this matter pretty carefully, and determined this fact by careful analysis and investigation, and it is the one reason why in our hot process we feed lime. In no case have we ever succeeded in throwing down by heat more than 60 per cent of the carbonates contained in the water, and the average result is not over 15 or 18 per cent. It doesn't make any difference how long the water is maintained at this high temperature, unless it is in a state of ebullition. For instance, if you hold the water at 212 deg. for 4 hr. in a state of quiescence, which it would be in in the body of the heater, you will not obtain a precipitate to exceed 25 per cent of the carbonate content of the water.

F. F. VATER.

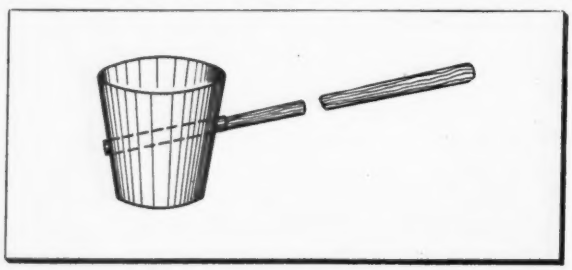
Explanation of Compound Feeder Trouble

I WAS much interested in the article in Dec. 15 number, by R. M. Packingham, entitled "Compound Feeder," and while I agree with him in regard to the velocity of water overcoming the extra head of barrel, I think he has not gone far enough with his explanation. If he will attach a pressure gage to his suction line he will find that between the strokes of his pump he will have a pressure which is far greater than enough to overcome the head of barrel. From his sketch I should say he has a globe valve in his compound line, set in such a manner that when the valve is slightly open, the lost motion in the valve converts it into a check valve and the pulsations of water in his suction line convert the whole apparatus into a miniature hydraulic ram. This would not only overcome the head of barrel, but would force the water to a far greater height.

B. A. MOUNTFORD.

Grouting With Sulphur; Broken Crank

WE HAD a large engine which got out of line, owing to poor foundation under the cylinder, and decided to fix it up and grout it with sulphur. After the foundation was repaired, the engine was lined and made ready for grouting. A large iron kettle was procured, sulphur put in, a slow fire of wood chips kindled and a cover made for the kettle, so the sulphur would not take fire. A tin bucket was converted into a ladle, by a tinner soldering a tube obliquely through the bucket, the tube being



LADLE FOR HANDLING SULPHUR

a socket for a wooden handle. This made a good ladle, as it was of light weight and would hold quite a quantity.

Sulphur must be poured very fast, as it cools rapidly; when heated, it must not be on the fire too long, as it will not flow so well, being something like molasses. If the fire is too hot, it will easily catch fire; if it does so, put a lid on the kettle and smother the flames. Before pouring the sulphur, the foundation must be free of oil; but after sulphur is cold, oil will not affect it. Here it has the advantage of a cement grouting, as the latter will disintegrate if soaked with oil. Sulphur will run in a very small opening.

A machinist was called to replace a broken crank on a Corliss engine. He found the engine in a dark corner, down in a cellar. The break was caused by water in the cylinder. The exhaust pipe ran through a pit or sump, which contained water enough to come part way up on the pipe. The drain on the exhaust pipe drained into the sump, but this time it was just the opposite. When the engine ran it acted as a pump and pumped the water into the cylinder, and the break followed. The owner asked the machinist what could be done, as that was the second or third crank that had been broken, and he wanted no more. He was told to keep the pit drained. The owner said the pit was below the level of the sewer in the street. He was then told to get a small belt-driven pump, and run it from the engine. Something like this was afterward done.

TOM JONES.

Chimney Capacity and Draft

MR. O'NEILL'S explanation, in the Oct. 15 issue, of chimney capacities is not very plain to me. He states, in part: "And this force will be equal to the difference in weight between the chimney full of hot gas and an equivalent column of cold outside air."

Why does increasing the height of the stack increase the tendency of the cold air to rush up and push the hot gases out, assuming a chimney 150 ft. high, containing 150 cu. ft., filled with gas at 500 deg. F.? Its weight would be practically 6.5 lb. Now, if we compare this with an equal column of outside air and double the height of the chimney, we have doubled the weight of the gas in the chimney (that is, if the temperature remains constant). We doubt the like column of air outside. It is plain, then, that the weight of gas in the stack and the air outside stay proportioned the same regardless of the height; so now, where does he get his theory for the difference in pressure?

The gas is being forced out against a pressure of air that is practically equal to the pressure that is tending to push it up the stack.

J. W. D.

It is customary to state the force of draft in terms of inches of water, which, of course, is independent of the area of the chimney. But in any given chimney, it is the difference in weight between the chimney full of hot gas and an equivalent column of cold outside air, that causes the chimney gas to be displaced by the outside air coming in through the furnace.

The statement that the chimney gas is forced out against a pressure of air that is practically equal to the pressure that is tending to push it up the stack is interesting but misleading. It is true that both pressures are nearly 15 lb. per sq. in. absolute; but the pressure per square inch at the base of the stack inside is a fraction of an ounce less than the pressure at the same level outside of the chimney. With a dense fluid like water, this slight difference in head would cause only a very slow movement; but it is enough to induce a high velocity in the case of an extremely light substance such as a gas.

The fact that the weight of the gas inside of the chimney and that of an equivalent column of air outside

of the chimney remain proportionate to each other, regardless of the stack height, means nothing, for otherwise a stack 1 ft. high would produce as much draft as a stack 400 ft. high. It is the difference in the weight that causes the movement. Thus, doubling the chimney height, doubles the weight of the inside and of the outside gases, and doubles the difference in weight.

It has been found in practice, that the relationship between draft head and velocity for a gas under low pressure, is practically the same as that between pressure head and velocity for water; that is, pressure head or draft will produce a velocity or be transformed into velocity head, where

$V = \sqrt{2 g h}$ (Neglecting chimney friction, leakage, and radiation losses.)

V = velocity feet per second.

h = draft expressed in feet of a column of the chimney gas, taking care of its density.

Assume a chimney 100 ft. high, with the gas ⅓ as dense as the outside air:

$$V = \sqrt{2 \times 32.16 \times \frac{1\frac{1}{3}}{\frac{1}{3}} \times 100}$$

$V = 8.08 \times \sqrt{200}$ ft. per second.

To transfer inches of water into feet head of gas; multiply inches of water draft by 1/12 of the ratio of the density of water to the density of the chimney gas.

With a given velocity the capacity of a stack varies with the area.

$Q = K A V = K_1 A \sqrt{2 g D} = K_2 A \sqrt{2 g h}$,

where D is inches of water draft, h is height of stack in feet.

For more complete discussions, see Merriman's "Hydraulics," Kent's "Steam Boiler Economy," Peabody and Miller's "Boilers" and Lucke's "Engineering Thermodynamics. HAYLETT O'NEILL.

Priming A Centrifugal Pump

RELATIVE TO Mr. Peterson's problem mentioned on page 1149, of the December 1 issue of Practical Engineer, I beg to state that he went to a whole lot of unnecessary trouble and expense in rigging up the ¾-in. pipe, as shown in the sketch accompanying his article. He could easily have overcome his trouble by making a pipe connection from the highest point in his circulating pump casing and connecting it to the condenser shell. He could have started up his outfit by first turning steam into his dry vacuum, and working up a vacuum of about 10 in., until the circulating pump suction pipe and pump casing filled with water. The valve on the discharge side of his circulating pump would have to be closed. He could then start his pump going and open the valve on the discharge.

Careful note should be taken that the stuffing boxes on the pump shaft are properly packed and tight. He should look out for air leaks in the suction line, as a small leak will affect the pump. In most cases, where a connection cannot readily be made from the volute of the circulating pump to the condenser proper, a vent cock, provided at the highest point, will relieve the pump of all the air. NATHAN OWITZ.

Compression in Corliss Engine

IN REPLY to M. W. in Sept. 15 issue and J. C. Hawkins in Nov. 1 issue, the compression in a steam engine is for the purpose of bringing the piston, piston rod, crosshead and connecting rod to rest at the end of the stroke without undue stresses on the bearings. Now, one can imagine the heavy stresses that these parts would cause if there were no way of overcoming this evil; that is why we use compression, and also to keep the clearance spaces filled with exhaust steam. But if one has the proper amount of compression for smooth running, the clearance spaces will always be filled.

When an engine has the proper amount of compression the piston and above-mentioned parts act just like a ball would in a pipe with a spring in each end; the ball would be stopped without a bump, as it would be rolled from one end to the other.

My experience teaches me that nearly all engines require different amounts of compression; therefore, I decide by tests as follows. (This applies to all 4-valve engines governed automatically with a regular speed; for irregular-speed engines one should get the best average.) With the indicator on, see that the crosshead pin is a neat running fit in the connecting rod bearing, then set your crankpin bearing loose enough to cause a small bump, just so it is noticeable. With the engine at full speed, with the eccentric properly set, start to adjust the exhaust valves and you will notice a difference in the sound of that pump on the crank, at the same time watching the cards. The smoothest running position is the proper compression for that engine. It is understood that all other events are to be corrected before this test. Now key up the crankpin and you will have a smooth-running engine. CHAS. E. BRACKEN.

Boiler Capacity

IN PRACTICAL ENGINEER for Dec. 15, page 1204, I find the article, "Increasing Boiler Capacity."

To increase the capacity of the boiler in question all that is necessary is to increase the grate area from 20 sq. ft., which is probably 4 ft. by 5 ft., to 33½ sq. ft.—that is, to install grates 5½ ft. by 6 ft. The boilers being 64 in., the sides can be slanted so as to give enough room from wall to wall to allow the installation of grates 5½ ft. by 6 ft. The forced draft should be so run as to furnish enough force to overcome fire resistance. Fires should be carried between 5 and 6 in.; this will be equal to burning coal between 25 and 30 lb. per sq. ft. per hour or a total of 837.5 lb. per hour, figuring on 5-in. fire; if 1 hp. is developed on 5 lb., the capacity will be 167.5 or about 170 boiler hp. with 5-in. fire. With 6-in. fire proportionately larger horsepower will be developed, but the ratio from tube area to grate will be so small that it will occasion a loss of draft, say, from 0.25 to 0.30 in. of water.

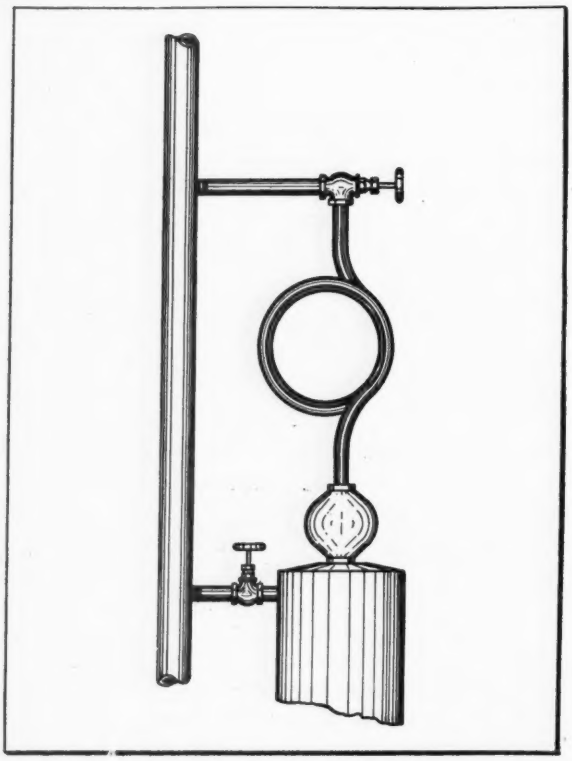
The title, "Increasing Boiler Capacity," is not correct, because the capacity of the boiler is not known and the capacity referred to is the commonly accepted standard under given operating condition and does not refer to the capacity of the boiler, as any boiler can be made to develop proportional horsepower to the heat delivered for absorption. H. MISOSTOW.

Successful Kinks From The Plant

For Saving Time, Work and Trouble

Lubricator Connection

SOME YEARS ago I piped up a steam engine and when about to connect the cylinder lubricator to the steam pipe, I found that the ¾-in. hole for the body of the lubricator connection and ¼-in. hole for the pipe leading to the condensing chamber, were not spaced apart far



LOOP IN LUBRICATOR PIPING

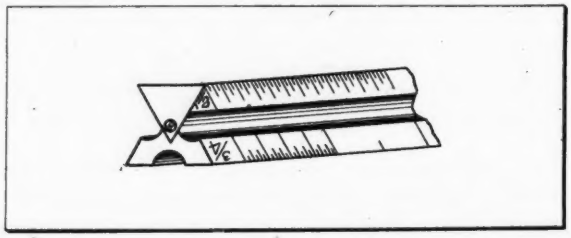
enough as called for in the directions of the makers of the lubricator. As no tools were handy to drill and tap another hole farther up on the pipe to make the required distance, to get out of the difficulty I made a circle connection out of brass pipe, as shown in the illustration, which did the work fine. H. JAHNKE.

Emergency Dashpot Rod

THE ELECTRIC light plant is right across the street from our plant and night before last the dashpot rod on the crank end of the engine snapped in two, putting the town in the dark. Mike is a pretty good chap, but he was stumped; there was no way to make a new rod, and chase the left-hand threads. It was 8:30 p.m., and the phone was raising cain, with the people calling for lights. Mike called me over and we went into a council of war, finally hitting on the plan of cutting a piece of 2 by 4 scantling long enough to stop the valve arm at its proper place on closing the valve; then, getting a piece of ⅜-in. flexible wire cable, we made a loop over the pin on the valve arm and connected this to the pin in the dashpot plunger. Upon starting up, she picked up right along, the pot closing the valve and the 2 by 4 stopping it right for the hook. The job took about 20 min. and we made the night run. T. M. STREET.

Indicator for Triangular Rules

WHEN USING the common form of triangular rule, the draftsman must be continually on the alert to avoid turning the rule over and using the wrong scale. But if a small equilateral triangle, ½ in. on each side, be cut



ATTACHMENT FOR TRIANGULAR RULE TO PREVENT MISTAKES

out of sheet metal and pivoted at one end of the scale by means of a small round-head wood screw, this plate can be turned so that only the proper side of the scale will rest on the drawing. This greatly reduces the chance of error and enables the draftsman to concentrate his attention on the drawing. MURRAY FAHNESTOCK.

To True Up Rim of Flywheel

IN THE plant where I am employed we have an engine with an 8-ft. cast-iron flywheel which was ⅝ in. out of true at the rim; this gave the engine a bad appearance while running. We were at a loss as to how to remedy it, except by turning down the rim and then using counterweights to rebalance it. Then we learned, by removing the governor from the wheel and by using a 2-lb. peening hammer, that we could peen the spokes next to the hub, and that would swing the rim of the wheel whichever way you wanted it to go. We did this to our wheel and it now runs as nearly true as it can be made to run. G. R. S.

(This seems rather a dangerous remedy and should be resorted to only with extreme care.—EDITOR.)

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Strength of Boiler Flue

A BOILER flue is made of ¼-in. iron, 18 in. in diameter, and in sections 6 ft. long, the end of each section being flanged and riveted to the next section with a reinforcing ring between the flanges. What is the maximum allowable stress in pounds per square inch?

A. R.

A. Fairbairn gives the following rule for the collapsing pressures of flues: Multiply the square of the thickness in inches by 806,300, divide by the length of the flue in feet and the diameter in inches.

Taking your figures, this gives $0.0625 \times 806{,}300 \div (6 \times 18)$, which works out 467 lb. per sq. in. A reasonable factor of safety for boiler flues would be 10, giving as a working pressure 46.7 lb.

The method of construction that you have described is known as the Adamson ring. The Board of Trade Rules for the Adamson ring are as follows: Divide the length of a section in inches by 67.5 times the thickness in inches; subtract the quotient from 5; multiply the remainder by the thickness in inches and by 8800, and divide by 3 times the diameter in inches. The quotient will be the working pressure in pounds per square inch. Carrying through these operations, we get 29.75 lb. as the working pressure, which is considerably less than that given by Fairbairn's formula. The Board of Trade Rules are intended to be over conservative in the matter of safety.

Boiler Setting

WHAT IS the best way to set 2 60-in. horizontal tubular boilers? Describe fully. S. B.

A. The best setting for 2 60-in. horizontal return tubular boilers depends on several factors, none of which are given with the question.

For anthracite coal, the ordinary setting is a very good one, while for long flame bituminous coal, it is probably the poorest that could be devised, as the grate is so near the shell that there is insufficient space for the complete burning of the gases which are distilled during the coking period.

If the grate must be set under the boiler, its distance from the shell should not be less than the diameter of the boiler.

The ash pit floor should slope from the bottom of the ash door to the floor level. The brickwork around the brackets must be clear so that the walls will not be pushed out of place by expansion. The inside walls should start to slant outward just above the grate to a line 5 in. under the brackets, giving an air space of 3 in. between sides of boiler and the inside of the wall. Fire brick in the furnace should be laid with headers every 6 courses, so that portions of the wall may be easily taken out and repaired at any time. The rear connection should be covered in with a fire-brick arch supported by cast-iron arch bars. The ends of the arch

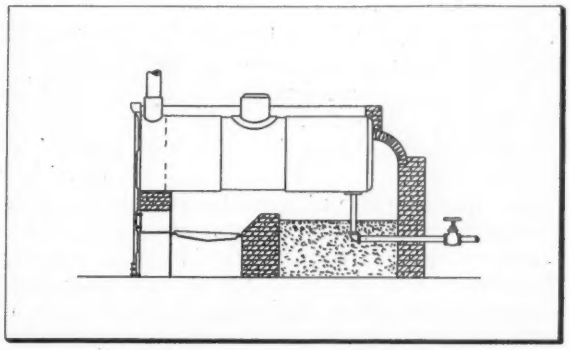


FIG. 1. COMMON TYPE OF BOILER SETTING

should rest on the side walls, and the rise of the arch should be sufficient to permit of easy access to the tubes at the rear end. A space of 1 in. should be left between rear end of boiler and inside of arch, so that expansion of the boiler will not affect the brick work. The boiler should be covered on the top to prevent radiation of heat. In case the boiler is covered with brick, an air space should be left between top of boiler and brick.

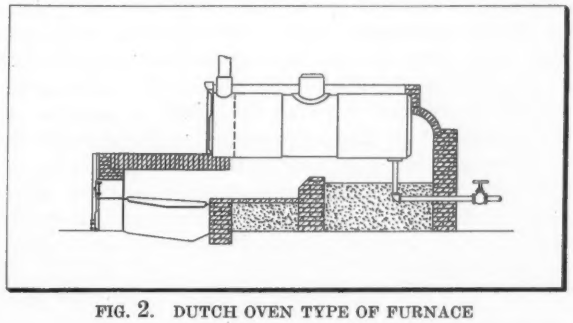


FIG. 2. DUTCH OVEN TYPE OF FURNACE

The dutch oven shown in sketch makes a good setting for the burning of most kinds of bituminous coals, though some require a greater distance from grate to shell than obtains with the common oven. In one instance the best results were obtained with a grate 14 ft. from the boiler. F. L. J.

THE COUNCIL OF WILMOT, Ark., passed an ordinance granting to Maingault & Graham of that city a franchise for an electric light and water system for 30 yr., and a contract for street lights has been signed.

Engine and Pump Questions

Is THE clearance volume of a cylinder to be expressed as a certain per cent of the volume of the whole cylinder or just the volume that the piston passes through?

2. Will a common duplex pump run if the lost motion is taken from the valve?

3. The inspector for my district claims the valve travel of a slide-valve engine depends on twice the throw of the eccentric. Is this right?

4. Is a butt joint with one cover-plate stronger than a lap joint? If so, why?

5. If the valve stems of a duplex pump were both direct connected to the rocker arms, the pistons would both run to one end of the stroke and stop. If they were both indirect they would run to opposite ends and stop. Is this right?

6. What is the relation between the area of a spring loaded valve and the grate area expressed as a ratio?

7. Do all duplex engines having a link motion and a variable cutoff use negative lead? How is the eccentric placed in relation to the crank when negative lead is desired? F. A. L.

A. The clearance of an engine is expressed in percentage of the piston displacement irrespective of what the entire volume of the cylinder and its connecting ports, etc., may be over and above the space actually passed through by the piston during one revolution. In the small high-speed engine with a single valve or with multiple valves with nonreleasing gear, the clearance from necessity must be much larger than in engines of the slow-speed, releasing-gear type (Corliss engine), owing to variable compression.

In the slower-speed Corliss engines, where the compression is constant, the clearance is much lower, being on an average about 5 per cent of the piston displacement, with 6 and 4 per cent as the 2 extremes, while in the small engines having high-speed and variable compression, the clearance runs from 7 to 12 per cent, with an average of 9 or 10 per cent.

2. As the steam valves of a duplex pump have no lap, when they are set central, their working edges are line-and-line. Some sort of a lost motion arrangement must be provided to permit the piston to pass through the stroke before moving the valve of the opposite side. As this lost motion is reduced, the stroke is reduced, and if it be entirely eliminated the pump will not operate more than half an inch or so at every stroke—simply enough to reverse the valves. In this condition it cannot do any work.

3. This is a question upon which authorities differ. Some maintain that the throw of an eccentric is the diameter of a circle described by the center of the eccentric as it rotates around the shaft, while others who, however, seem to be in the majority, maintain that it is but half of this amount, or the radius of the circle described by the center of the eccentric, which would be half the valve travel.

As a rule, engineers use the latter meaning, which is in accordance with the views of the inspector in your district.

4. A butt joint with one cover plate is so seldom used that there is no data pertaining to it. It is never used in boiler construction and its use is confined to tank work or receptacles, where it is necessary, for obvious reasons, to have the interior free from joints of rivet heads, and in cases like this, countersink head rivets are used.

As far as the joint is concerned, with a given data as to radius, thickness and tensile strength of plate, and pitch and diameter of rivet, a butt joint with one cover plate is to all intents and purposes, a double lap joint, and would be computed the same as for a lap joint with the same data.

5. Yes. The reason that one of the valve stems is driven by an indirect motion and the other by a direct motion is to provide a means of securing reversal and continuity of motion. Were this not provided for, and both valves driven by either a direct or an indirect motion, the pump would move to one or the other end of the stroke and stop, for the reason that the valves would be in that position to hold the pistons at the end and no means to reverse that position.

6. The area of a spring loaded safety valve (or a lever valve for that matter) depends upon the pressure and the amount of fuel burned per square foot of grate surface per hour.

The ratio of square feet of grate surface to square inches of safety valve disc, ranges all the way from 2.5 sq. ft. to 1 sq. in. for low pressures up to 4.5 to 1 for the highest pressures.

The formula used by the Government Board of Supervising Inspectors is as follows:

$$a = 0.2074 \times \frac{W}{P}.$$

Where, a = area of safety valve, in square inches, per square foot of grate surface.
W = pounds of water evaporated per square foot of grate surface per hour.
P = absolute pressure per square inch (= working pressure plus 15).

7. Not necessarily. It all depends upon the service or the nature of the work, and not a little upon the whims of the person who has charge of the valve setting. Take, for instance, on railroads where the valve setting usually comes under the direction of the master mechanic.

The practice on a number of different roads in the central and eastern states, with full gear forward, is all the way from 1/32-in. positive to 3/16-in. negative lead, and in full gear backward, all the way from line-and-line to ¼-in. negative.

Engines having link motions are generally used where the starting load is extra heavy and where compression counts for nothing, but where the link is "hooked up" with the increase of speed, compression begins.

After having set the valve for equal travel, the question of positive or negative lead is determined by the advance of the eccentric and its position is regulated by the design (direct or indirect motion) and by the amount of lap, etc. Place the engine on the center and with the link in full gear, advance the eccentric in the direction in which the engine is to run till you have the desired lead, whether negative or positive.

G. H. Wallace.

Storage Battery Questions

WHAT SHOULD cause the changing color of the plates of a storage battery? The positive plate changed to a slate color and the negative to a brown. Is it possible for them to change polarity?

2. Why has a storage battery one more negative plate than positive?

3. What should cause certain cells not to gas?

4. What is the use of a vibrator on an automobile?

A. M.

A. The change in color of plates of a storage battery when charging and discharging, is due to the change in chemical composition of the paste which is used to make up the plates.

One plate has lead oxide, the other lead sulphate, and the action in charging and discharging changes these back and forth to lead sulphate and to sponge lead. These materials have different colors, which explains the changes.

There is no possibility of changing from one polarity to the other. If an overcharge is given, it simply results in heating the liquid, and possibly making the battery boil.

2. Current inside a storage battery flows from the negative plate to the positive. It is, therefore, found advisable to have a negative plate at each end of the cell, so that the current will flow in towards the adjoining positive plate at each end. There might, of course, be one more positive plate than negative, but as a matter of fact, it is found that in charging, it is desirable to have more negative plate service than positive.

3. Gassing in a cell during the charge is caused by charging too rapidly; that is, at too high a voltage or by overcharging; that is, continuing to send in current after the battery has taken up all the energy it can store. The only thing that would cause one cell not to gas when the others were gassing, might be the fact that it was discharged more than the others, by some process, and so had not reached its full charge as soon as the others.

4. The vibrator in an automobile is to set up the jump spark. When this is used, the current, either from the battery or the low tension magneto, is sent through an induction coil, which is a simple kind of transformer for raising the voltage. This high voltage from the second coil of the induction is sent through the ignition plugs to jump across between the points, and thus give the spark.

In order to get the transformer action in the coil, it is necessary to have the current rapidly made and broken, so that the magnetism may be varied rapidly in the iron core. The vibrator accomplishes this rapid make and break. It operates exactly the same as the vibrator in a door bell. When the circuit is made, the magnet attracts its armature and one of the contact points, which is attached to the armature, is thereby pulled away from its mate and the circuit is broken. As soon as the circuit breaks, the spring on the vibrator throws the points back into contact, current flows, the magnet attracts the armature and pulls the points apart, and the process is repeated as long as the timer holds in contact.

A. L. R.

Saving Due to Condensing

WHAT SAVING would there be on a Corliss noncondensing engine, 26 by 48 in., running 52 r.p.m. if we ran the engine condensing at 20-in. vacuum, steam pressure 100 lb.

J. C. J.

A. Numerous tests made by experts show that with the usual vacuum of 26 in. there will be a decrease of about 20 to 25 per cent in the steam consumption of the engine. From this must be taken the amount of steam used by the air and circulating pumps. Where all the exhaust steam can be utilized for heating the feed water, the change from noncondensing to condensing will show a much lower per cent of saving.

With exhaust steam at 2 or 3 lb. absolute pressure the feed water cannot be heated over about 125 deg. unless there is an auxiliary heater used, in which the exhaust from the pumps at higher pressure is used, whereas when running noncondensing the water may be heated to 210 deg. The saving by heating the feed water with exhaust steam is usually figured at 1 per cent for every 10 deg. the water is heated, which would be about 8.5 per cent to be deducted from the gross saving made by running condensing.

Then there is the overhead and maintenance charges on the condenser and its equipment that must be taken out of the amount of saving figured. If, however, there is enough exhaust steam from the auxiliaries to heat the feed water, as there would be in a large plant, the saving due to lower back pressure will be greater.

The saving to be made also depends on the load, point of cutoff, piston speed, boiler pressure and condition of the engine.

The inquirer only desires to carry 20 in. of vacuum, which is very low, and not knowing all the circumstances, it would be hard to give any figures that would be of practical value to determine the saving that could be made, but from a theoretical point of view, provided the engine is fairly loaded and the exhaust can be used for heating the water or in the heating system, the saving made in this case would be from 5 to 8 per cent of the steam used, or with no use for the exhaust steam it would be about 15 per cent of the steam used.

The only way to determine this with any degree of accuracy would be by test. If the inquirer wishes to install a condenser I would suggest that he take the matter up with some manufacturer of condensers, giving all the information and data. These people are experienced in this particular line, and from their past wide experience could give a definite figure for the saving that could be made by this change.

J. C. HAWKINS.

Feed-Water Heater Economy

HOW MUCH does an exhaust feed-water heater add to the economy of a power plant?

A. One per cent for each 10 deg. rise of feed-water temperature.

A LARGE POWER PLANT will be erected in East Waco, Tex., by the Texas Power and Light Co. The building and equipment will cost nearly $1,000,000, according to representatives of the construction company awarded the contract. The plant will be used in furnishing electricity to cities within 100 miles of Waco.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Knock In Engine

I AM running a Monarch 500-hp. cross-compound condensing engine, direct attached to 250-kw. a.c. generator, at over 125-lb. steam pressure. A knock develops in the crosshead when the load is light. When pulling heavy load or there is low steam pressure, it is not noticeable at all. There is apparently no play in the crosshead. Can anyone explain why it does this?

G. L. K.

Submerged Water Main

I SHOULD like to get the experience of others in the laying of water mains, 4 or 6-in. pipe, under a stream. It is the usual type of western stream, with soft banks and a heavy flow in spring and a light flow in summer.

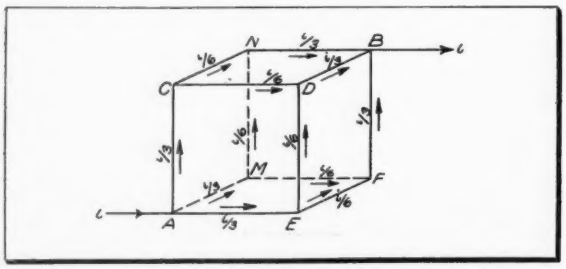
Can anyone give information as to the best method of making joints, how to lay the pipe and how to make connections?

C. D.

Resistance Problem

REFERRING TO the problem in resistance of 12 wires arranged to form a cube, by H. S. in the Dec. 1 issue, I submit the following solution, rather practical than theoretical. We are given the condition that each length of wire has a resistance of 1 ohm.

In the skeleton cube shown by the figure, assume that a current of i amperes enters from a lead at junction A and leaves at junction B. At A the current finds 3 paths, each having the same resistance, since the



SKETCH OF CIRCUIT, SHOWING DIVISION OF CURRENT

figure is symmetrical. Therefore, wires A E, A M, and A C will each conduct i/3 amp. At C the current finds 2 paths of equal resistance, and the wires C D and C N will each conduct ½ of ⅓i or i/6 amp. Similarly E D, E F, M N and M F each conduct i/6 amp. At N the currents from C N and M N meet and uniting pass through N B, amperage being the sum of $i/6 + i/6 = i/3$. Similarly D B and F B conduct i/3 amp. At B these 3 currents meet and leave the skeleton cube by the other lead, amperage $i/3 + i/3 + i/3 = i$, which is the same current as entered the cube. Arrows in the figure show direction of currents.

Remembering that the resistance of each wire is 1 ohm, and that the voltage drop between 2 ends of a wire is equal to the resistance times the current passing through the wire, we have the voltage drop between A and $C = 1 \times i/3 = i/3$, between C and $N = 1 \times i/6 = i/6$, between N and $B = 1 \times i/3 = i/3$.

The voltage drop between A and B is the sum of the voltage drops between A and C, C and N, N and B, which equals $i/3 + i/6 + i/3$ or 5/6 i volts. The current passing through the cube is i amperes, so that the drop in voltage from A to B divided by current—i amperes—will give the resistance of the skeleton cube, or $5/6\,i \div i = 5/6$ ohms.

The voltage drop from A to B along any path whatsoever will be found to be 5/6 i volts as given above. The resistance will also be found to be as given above if the problem is solved algebraically, using formulas involving resistances and conductances.

D. FLIEGELMAN.

SOLUTION OF Resistance Problem, is greatly simplified by the use of the 2 diagrams attached. Figure 1 is the figure as presented in the problem, but with identification numerals and letters for comparison with Fig. 2, which is a development of the circuits of Fig. 1, but showing more plainly the paths of the current. Figure 2 is also divided into convenient sections, X, Y and Z, to facilitate the solution of the problem.

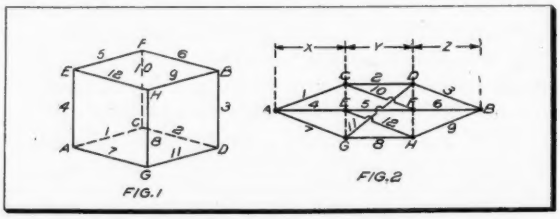


FIG. 1. DIAGRAM OF THE RESISTANCE PROBLEM
FIG. 2. DEVELOPMENT OF CIRCUIT SHOWN IN FIG. 1.

Each length of wire representing an edge of the cube has a resistance of 1 ohm. The joint resistance of any number of resistances is the reciprocal of the sum of the reciprocals of each separate resistance. Then the resistance of section X would be:

$$\frac{1}{\frac{1}{1}+\frac{1}{1}+\frac{1}{1}} = \frac{1}{3}$$

and of section Y:

$$\frac{1}{\frac{1}{1}+\frac{1}{1}+\frac{1}{1}+\frac{1}{1}+\frac{1}{1}+\frac{1}{1}} = 1/6$$

and of section Z:

$$\frac{1}{\frac{1}{1}+\frac{1}{1}+\frac{1}{1}} = \frac{1}{3}$$

The total resistance of a number of resistances in series is the sum of their resistances; therefore, the resistance of circuit A-B = X+Y+Z = $\frac{1}{3} + 1/6 + \frac{1}{3} = 5/6$ ohm. ROY W. EVES.

IN ANSWER to Resistance Problem, I submit the following:

Imagine the cube to be flattened out, as shown in Fig. 1; then, if the circuit were connected or subjected to a difference of potential such as to cause a flow of 1 amp. from A to B, the distribution of 1 amp. would be as follows:

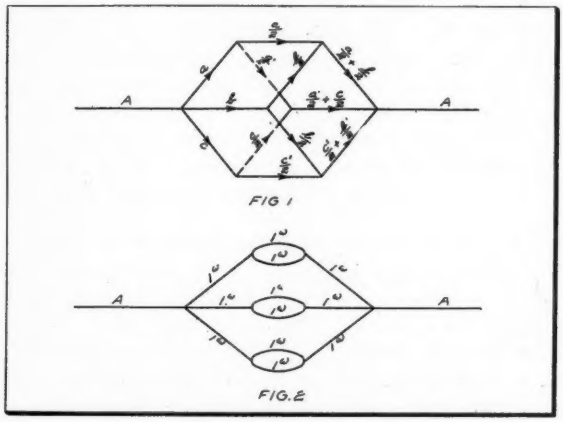


FIG. 1. DIAGRAM OF CIRCUIT, SHOWING RELATION OF CURRENTS IN VARIOUS DIVISIONS

FIG. 2. DIAGRAM SHOWING RESISTANCE OF THE VARIOUS SECTIONS

1/3 amp. through a, 1/3 amp. through b, 1/3 amp. through c; 1/6 amp. through a/2, 1/6 amp. through a′/2, 1/6 amp. through b/2, 1/6 amp. through b′/2, 1/6 amp. through c/2, 1/6 amp. through c′/2. Through the terminating edges of the cube the current will divide equally, although there will have taken place an interchange, due to the intermediate cross connection. It can be seen that the circuit is electrically symmetrical and diagrammatically can be resolved into the circuit shown in Fig. 2, which lends itself readily to solution: 3 circuits of 2½ ohms each, being in parallel, reduce the joint resistance to ⅓ of 2½ which equals 5/6 ohm. Ans.

Letting a, b and c represent the current entering as shown in Fig. 1 and the distribution will be as indicated. AMOS J. CARR.

Hard and Soft Boiler Patches

IN ANSWER to F. E. K.'s query, "Boiler Patches," on page 1203, Dec. 15 issue, he seems to be laboring under the assumption that the words "hard" and "soft" have reference to the kind of metal used in the patch.

Hard patches are such as are seen almost everywhere and are plates of metal bent or pressed to proper shape to cover the place they were intended for at the shop or factory, then riveted in place. The injured part of the boiler is cut out and then the holes are laid out to correspond to the rest of the boiler (these are usually punched); they should be drilled 1/16 in. larger than the rivet that is to be used. After all holes are made in both shell and patch, the rivets are driven, and then the rivets and seams are calked and all ragged places are trimmed up nicely to make the job look workmanlike.

The above would apply to "soft patches" in reference to shaping and fitting only. I have no data at hand in regard to the size of holes to be used in soft patches, but my own judgment says they should be snug fit to the bolts or cap screws. Soft patches are bolted to the plate and should never be used where it comes in direct contact with the fire.

When placing the patch, the sides that come in contact with one another should be well coated with red lead, and then the bolts securely screwed down. Soft patches are only makeshifts and should be used only in emergency and removed as soon as possible and a hard patch used instead. ISAAC M. SMITH.

Refrigerating Trouble

IN ANSWER to B. C. W.'s refrigerating troubles mentioned in the Dec. 1 issue of Practical Engineer, he can do no better unless he runs 24 hr., for he gives a good idea of the condition of his plant, and it seems he is getting all he can out of it; we have had warmer weather this season than we did last season. C. A. C.

Heating Surface Required

I WISH to heat the fourth story of a building standing on a hill exposed to all winds and especially the winds of Lake Erie. The outside dimensions are 110 ft. by 130 ft., 11½ ft. high, flat roof, heavily covered with cinders and 3 courses of tar paper. Building is constructed of brick, iron and concrete—this means concrete floors and ceiling for the fourth floor under consideration. There are 24 windows, with dimensions 14 ft. by 8 ft. Please let me know how many feet of 2-in. or 1½-in. pipe it will take to heat this room in zero weather outside to 80 deg. inside temperature with steam delivered on the floor at 60 lb. pressure, then delivered through the coils at 10 lb. pressure through a reducing valve. Please state whether a 2-in. delivery pipe from boilers to reducing valve would be big enough or not. A. L.

THE BOARD OF MANAGERS of the Missouri School for the Deaf, at Fulton, Mo., recently decided to complete the new power plant at the institution at an estimated cost of $9000. Bids will be received in January and the work will be done during the vacation period. Several new boilers and other equipment will be purchased.

PRACTICAL
ENGINEER

Trade-mark reg. U. S. Pat. Office.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH
At 537 So. Dearborn Street, Chicago, Ill., by the
TECHNICAL PUBLISHING CO.
New York, 150 Nassau St. Cleveland, Am. Trust Bldg.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyrighted, 1914, by Technical Publishing Co.
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Circulation of this issue, 23,500.

CONTENTS

Control System for Panama Canal Locks. Illustrated.....135
Laying Up the Plant. By J. C. Hawkins. Illustrated.....140
Heating and Ventilating Large Buildings. By Charles L. Hubbard. Illustrated 141
Melting Point of Commercial Copper Alloys.....144
About Drafts and Draft Troubles. By Joseph W. Hays....145
Gas Engine Horsepower. By George W. Muench. Illustrated 148
Steam Transmission. By Arthur O. Gates.....150
International Engineering Congress of 1915.....152
Practical Electrical Engineering. By Norman G. Meade. Illustrated 153
Woven Wire and Cord Resistance. Illustrated.....157
Mica-Cutting Tool. Illustrated.....158
Voltage of Dynamo 158
Correspondence of an Old Engineer and His Son.....161
Foreign Development in the Power Plant Field. By J. H. Blakey. Illustrated 163
Double-Pipe Ammonia Condensers. By A. G. Solomon. Illustrated 164
Hospital Power Equipment. Illustrated.....165
Letters Direct from the Plant: Position of Valves on Steam Lines. Cooling Tower. Precipitating Carbonates from Water. Explanation of Compound Feeder Trouble. Grouting with Sulphur; Broken Crank. Chimney Capacity and Draft. Priming a Centrifugal Pump. Compression in Corliss Engine. Boiler Capacity. Illustrated....166
Successful Kinks from the Plant: Lubricator Connection. Emergency Dashpot Rod. Indicator for Triangular Rules. To True Up Rim of Flywheel. Illustrated.....170
Questions Answered and for Answer: Strength of Boiler Flue. Boiler Setting. Engine and Pump Questions. Storage Battery Questions. Saving Due to Condensing. Feed-Water Heater Economy. Illustrated.....171
Problems for Discussion by Readers: Knock in Engine. Submerged Water Main. Resistance Problem. Hard and Soft Boiler Patches. Refrigerating Trouble. Illustrated.174
Editorial: Plant Efficiency.....176
News Notes 177
Elliott Filters and Grease Extractors. Illustrated.....178
Davidson Multi-Blade Patents Sustained.....179
The Hunt Industrial Truck. Illustrated.....180
Spiroflo Surface Condenser. Illustrated.....181
Locating Losses in Belt Transmission.....182
Practical Reference Tables: Steam Transmission at Constant Quality. Properties of Saturated Ammonia.....183
H. C. Meinholtz.....185
Books and Catalogs.....185
Trade Notes 188

Plant Efficiency

In the past the average engineer has spent the greater part of his time that has been devoted to plant efficiency in the engine room in using the indicator, and experimenting with the valve setting of the engines to get a more perfect card, which, after the valves are reasonably well set, is practically time wasted. Much time is devoted to keeping the general condition of the engine room and its machinery such that it will present a good appearance to the casual visitor; hours of valuable time are spent in keeping accurate records and data of the operation of the plant which, beyond being a pleasant pastime, is of no value unless the information contained therein is put to use in increasing the plant efficiency, which too often is not done. All this, with the idea of increasing the plant efficiency.

This is all very good, but of little value in increasing the overall efficiency of the plant. The greater part of this time is wasted because it is spent in the wrong place. This time belongs in the boiler room. The economy of the engines is fairly constant over a long period, but the efficiency of the boilers is seldom at the best, and conditions are changing constantly. Often the labor in the boiler room is of a grade that is less skilled in its line of work than that in the engine room, though it should not be. Too little attention is paid to the air supply, consequently combustion is incomplete. The gases are allowed to escape at too high temperature, cold air is allowed to leak in around the doors and through the setting, soot is allowed to accumulate on the tubes, and is only blown off at long intervals. Too little attention is paid to keeping partly burned coal out of the ash pit, and sometimes fresh coal is scattered into the ashes in firing. These conditions are changing all the time.

Firemen usually work hard in a poorly lighted room with no ventilation, cold and drafty in winter and exceedingly hot in summer. Whenever they have a moment to rest between firings it is invariably on an overturned box or hard plank, with no chance to rest the back. In many cases there are 2 shifts of 12 hr. each which, if reduced to 8 hr., will let the men give much better service and more economical results. Because the boiler room is let go and becomes an unpleasant place, the engineer spends no more time there than is necessary. He depends upon John to see that the boilers are clean, and looks to Bill to see that the coal consumption does not get too high, and to somebody else to see that the other things are attended to. It is no wonder that the efficiency is low.

Boiler and furnace efficiency of 50 to 55 per cent is common, although it has been demonstrated many times that an efficiency of 75 to 80 per cent is possible when the boilers are operated as they should be. In order to reach this figure the boiler room must have the undivided attention of the man responsible for its operation. He must be a well trained expert on combustion, he must test each boiler separately, and locate all of its weak points, keep close watch of the firemen or mechanical stokers, if they are used; know how the work should be done and see that it is done in the most economical manner.

Index for 1913

THE COMPLETE yearly index to Practical Engineer, volume XVII, is ready for distribution and will be mailed free to all subscribers who send a request for it.

Correction Note

IN THE Jan. 1 issue the following errors have been noted and the attention of readers is called to them, so that no confusion or misunderstanding will be caused:

On page 20 the first 2 lines on the page should be the last 2. Page 78, second column, fourth line, change word "conditions" to "connections." Page 84, first column, fourth paragraph, ninth line, transpose the decimal point, making the figure ".0188," as printed, read "0.188," as was intended. Page 132, the cut printed in connection with the note upon the Uehling vacuum recorder illustrates an Industrial Instrument Co. recording steam pressure gage and should not have been printed on that page.

News Notes

COMMENCING WITH the January issue, The Journal of The American Society of Mechanical Engineers includes the Transactions, and is the permanent record of the society, the republication in a separate volume as Transactions being discontinued. Therefore, The Journal should be preserved month by month, so that at the expiration of the year the 12 numbers may be bound as a whole, or the papers, foreign reviews, etc., divided and bound separately. An index will be published in the December issue, together with directions for binding. In the new form, The Journal will be 9 by 12 in.

ACTION ON MOTION to dismiss the case of the people of Illinois against Economy Light & Power Co. was postponed by the Supreme Court of the United States until the merits of the case can be gone into. The action is brought by the state to prevent the power company from building a dam across the Des Plaines River at Dresden Heights, on the ground that this river is navigable at that point, and is, therefore, a public highway. The deed for the site of the power development ran from the state to the Illinois and Michigan canal, and thence through H. T. Griswold to the power company. The suit against completing the dam has been carried through the county and state courts, with decision in favor of the power company, and the present action is a final resort by the state.

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for inspector of mechanical and electrical engineering on Jan. 21, 22, and 23, 1914. From the register of eligibles resulting from this examination certification will be made to fill a vacancy in this position, at $2000 a year, in the Office of the Supervising Architect of the Treasury, and vacancies as they may occur in positions requiring similar qualifications. Competitors will be examined in the following subjects, which will have the relative weights indicated: Practical questions in mechanical and electrical engineering, 50; drawing and design, 20; training and experience, 30. Applicants who do not show that they have had sufficient training and experience to entitle them to a rating of 70 per cent or more in this subject will not be admitted to the examination. The duties of the position consist of inspecting and testing the mechanical and electrical equipments entering into the modern Government or office building. It is desired that applicants shall have had practical experience in the design, construction, and inspection of work in the following branches of mechanical, electrical, and sanitary engineering: Heating and ventilating apparatus, plumbing, water supply and drainage, conduit and wiring work, elevators, vacuum cleaning systems, and electric generating plants. Age limit, 20 yr. or over on the date of the examination.

Persons who meet the requirements and desire this examination should at once apply for Form 1312 to the United States Civil Service Commission. In applying for this examination the title, "Inspector of Mechanical and Electrical Engineering (Male)," should be used.

WILLIAM C. DETTLER, consulting engineer, is preparing plans and specifications for a one-story concrete and brick power plant, to be erected at Harrisburg, Pa.

THE CIVIL SERVICE BOARD of the West Chicago Park Commissioners will hold an examination for Stationary Engineer, Class B, Grade I, Division Z, pay $80 to $100 a month, to be held Jan. 26, 1914, at 9:00 a.m. at Garfield Park Pavilion; open only to residents of the Town of West Chicago, between the ages of 25 and 55 yr., who hold a stationary engineer's license from the City of Chicago. Subjects: Special subject, weight of 6; experience, weight of 3; educational, weight of 1. Special subject: Written and oral questions to indicate the candidate's qualifications to perform the duties of Stationary Engineer, which involve immediate charge of the heating and ventilating plant in a park building during a definitely assigned watch, and the operation and maintenance of the high-pressure boilers, fans, electric motors and other auxiliary equipment in the building. Applications must be filed in the office of the Board in Union Park before 12 o'clock noon on Jan. 24, 1914.

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for aid on Jan. 21 and 22, 1914. From the register of eligibles resulting from this examination certification will be made to fill vacancies as they may occur in this position in the Bureau of Standards, Department of Commerce, at salaries of $600 and $720 a year and vacancies as they may occur in positions requiring similar qualifications.

Competitors will be examined in the following subjects, which will have the relative weights indicated: Elementary algebra, geometry, and trigonometry, 30; general physics, 30; elementary mechanical drawing, 20; education, training, and experience, 20. Graduation from a mechanical training, technical, or scientific school or equivalent training in a scientific or technical laboratory is a prerequisite for consideration for this position. Applicants must have reached their 19th but not their 24th birthday on the date of the examination. Persons who meet the requirements and desire this examination should at once apply to the United States Civil Service Commission. In applying for this examination the title "Aid (Male)," should be used.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Elliott Filters and Grease Extractors

IN the power plant field, it is necessary that water, free from sediment and trash, be used in the boilers, for cooling transformers and for condensing purposes. It is also necessary, where fuel oils are used, that these be free from sediment which will clog up the burner and give an endless amount of trouble. Cylinder oil which returns with the condensed steam from the condensers or heating system, is also a source of considerable danger in the boiler. To remove all these impurities and make the water fit for use in the power plant, is the purpose for which the Elliott filters and grease extractors have been designed.

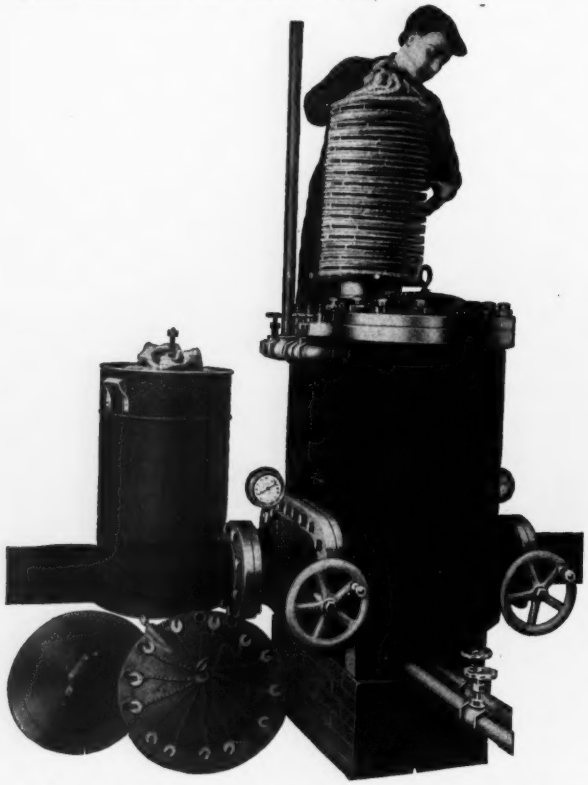


FIG. 1. CLEANING THE TWIN FILTER AND GREASE EXTRACTOR

These are built in 2 forms, known as the twin and single filter. They operate upon the same principle but are different in construction. The twin filter is of most service in the places where continuous service is required. As its name implies, the twin filter and grease extractor consists of 2 separate filtering chambers having a common base. Each chamber contains a complete filter, consisting of a double layer of Terry cloth mounted upon spreaders and spacers around a central vertical slotted column. The base of the filter is divided, and the 2 valves are arranged so that the flow of the liquid to be filtered may be directed into either or both of the filtering chambers. The valves, one of which is placed at either end of the base, are of the slide or gate type and are always tight when closed. To insure their being tight, wedges are provided within the covers of the base to force them firmly to their seats when directly over the ports leading to the filtering chambers.

When it is necessary for the filtering media in one of the chambers to be cleaned or replaced, this chamber may be cut out of the line by simply shifting over the 2 valves so as to close the ports leading to that chamber. When this is done the chamber is completely isolated from the line. The cover is then removed and the fouled interior replaced with a clean one at leisure, while the liquid is being filtered through the other chamber. The fouled filtering media may then be removed from the supporting spreaders and spacers, washed, dried, and later reassembled and stored in a can provided for that purpose until such time as it is necessary to use it again.

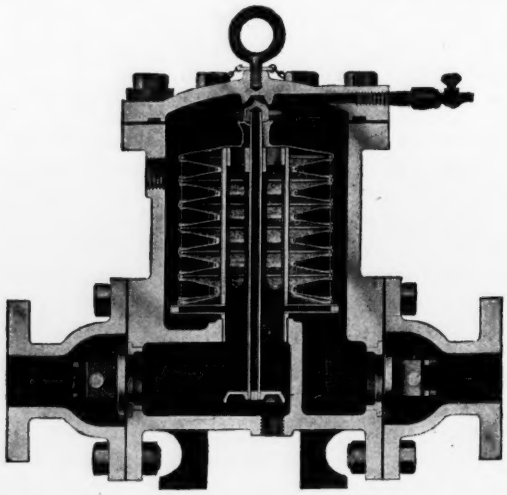


FIG. 2. VERTICAL SECTION THROUGH FILTERING CHAMBER

In cases of water filtration where the filtering media is fouled with sand, sediment, precipitates or anything of this nature, temporary relief from cleaning may be had by causing the water to flow through the filtering chamber in the reverse direction. This is accomplished by admitting water under pressure through the connection at the side and permitting it to escape through the con-

nection at the bottom of the filtering chamber, thus washing a large percentage of the precipitates on the inside of the filtering media into the sewer.

The twin filter, as stated above, is suited for all conditions of filtration service, but more especially those conditions where a constant and continuous supply of filtered liquid is necessary. Having 2 filtering chambers, one of the filters is in constant service, and in cases of emergency or sudden demands for increased quantity of filtered liquid, the valve in the twin can be moved to mid-position and both chambers put in service.

The single filter and grease extractor consists of a filter chamber containing the filtering media and a base containing the bypass. The base is divided, and the 2 valves, one of which is placed on either end of the base, are arranged so that the flow of the liquid may be directed either through the filtering chamber or through the bypass as desired. The interior construction of the filter chamber is identical with that of the twin; but when the filtering chamber becomes fouled from continuous use, and there is but one of these chambers, the flow of the liquid must necessarily be directed through the bypass, while the fouled interior is flushed out and replaced by a clean one.

Connections are provided so that when the filter chamber is cut out of the line, the direction of flow may be reversed to flush out the foreign substances retained on the interior surface of the filtering media.

The operation of the filter may be understood by referring to the cross-sectional view. The liquid to be filtered enters at the left from the pumps, passes up and out through the central slotted column, coming in contact with the filtering media consisting of 2 thicknesses of Terry cloth mounted on spreaders and spacers. This media removes the impurities, the filtered liquid passing into the surrounding chamber, down and out at the right into the line to the closed heater, boilers or where desired.

If the filter is being used to remove oils and greases from feed water, the necessity for cleaning will be determined by the amount of oil and grease in the water, as the filtering media can absorb this oil and grease only up to its point of saturation. If, however, the filter is being used to remove sediment, sand, precipitates, etc., from either oil or water, these foreign substances will accumulate on the inside surface of the filtering media and the necessity for cleaning will be indicated by the increased difference in pressure shown at all times by the 2 pressure gages, one of which is connected at the inlet and the other at the outlet of the filter.

Filtering media, Terry cloth, may be either cotton or linen, depending upon the service. Cotton Terry is used when the service required is similar to removing vegetable matter, sand, sediment, grit, etc., from water or from fuel or lubricating oils, while linen Terry is invariably used for service similar to extracting oils and grease from boiler feed water. The cloth is used double thickness, and is supported around a central column by spacers and spreaders. These are made of the strongest wire mesh and wire possible in keeping with their size.

Covers for the filtering chambers are of the quick adjustable type with inserted gaskets and are held in place by open washers slipped under the nuts on the studs. The covers may be removed by simply slacking off on the nuts so that the slotted washers may be withdrawn, for the holes of the covers are of sufficient diameter to clear the hexagonal nuts on the studs. The washers are attached to chains to insure their always being ready for replacement.

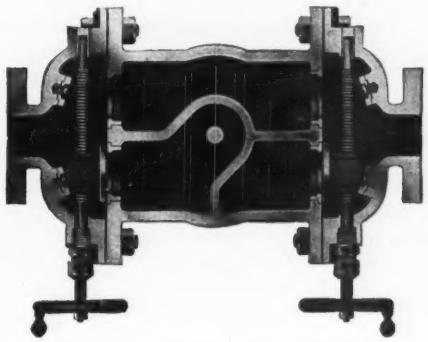


FIG. 3. SECTION THROUGH BASE OF SINGLE FILTER

Rating of these filters ranges in capacity from 20,000 to 250,000 lb. an hour in sizes from 2 in. to 7 in. inlet and outlet.

These filters are the product of the Elliott Co., of Pittsburgh, Pa.

Davidson Multi-Blade Patents Sustained

ON October 9, 1913, a decision was handed down by Judge Ray of the United States District Court for the Southern District of New York, sustaining and enforcing the fundamental Davidson patents owned by the American Blower Co., of Detroit, covering fans of the multi-blade or squirrel-cage type.

This suit, brought to suppress an infringement, has been under prosecution continuously since 1908, having been commenced by the Sirocco Engineering Co., which then owned the patents, and which was consolidated with the American Blower Co. in January, 1909, since which time the suit has been vigorously prosecuted by the latter company.

The patents involved cover inventions of S. C. Davidson, of Belfast, Ireland, whose Sirocco Multi-blade type of fan was introduced on the British market in 1898; the United States patent applied for in that year was issued in 1900; the fan was introduced on the American market in 1903 and was later taken over by the Sirocco Engineering Co., which commenced its manufacture in this country in 1907. Shortly thereafter a fan of similar design was put on the market, which was considered by the owners of the patents to be a flagrant infringement, and suit was at once commenced to restrain its manufacture. Depositions were taken at Belfast, Ireland, and at several places in the United States, the testimony covering numerous tests of fans, and the opinions of engineering experts, so that proofs occupied over 2 yr., resulting in a printed record of 6 volumes, aggregating over 3100 printed pages. The case was argued in January, 1913, before Judge Ray, at New York, by Arthur C.

Fraser and Frederick P. Fish, for the complainant, and Benjamin Phillips, for the defendant. Judge Ray had the case under advisement for nearly 9 mo., with the result that he has decided it sweepingly in favor of the complainant upon every point raised.

The Multi-blade Sirocco fan or blower has a small rotary member in the form of a drum, having numerous elongated, curved blades extended parallel to the axis of rotation and enclosing within them a large intake chamber, giving free access to a large volume of air, and, rotating at high speed, projects this air from the tips of the blades in tangential direction at high velocity.

The defendant contended that the patents were invalid, and technical objections were raised to the manner in which the Davidson patent was first issued and then later reissued.

The Court, after reviewing the claims of the patents in suit, holds that the Davidson invention is an improvement or advance in the art involving discoveries; that invention was involved in devising an improved construction with proper proportioning of parts or elements so as to move the greatest amount of fluid in a given time and secure the greatest possible efficiency.

The Court decides that the reissued patents were properly reissued to the Sirocco Engineering Co. as assignee; that there is no unlawful broadening of the claims in scope on reissue; that it was the purpose of the reissue to exclude everything covered by the prior act and include only the invention of Davidson so as to make the reissues more definite, certain and specific, but not to broaden the claims; that the patents in suit disclose invention and are valid and that there was no undue delay in applying for the reissues.

The word "Sirocco" is a general trade-mark of the American Blower Co., but the Multi-blade or Drum type "Sirocco" is the leading fan manufactured by this company.

The Hunt Industrial Truck

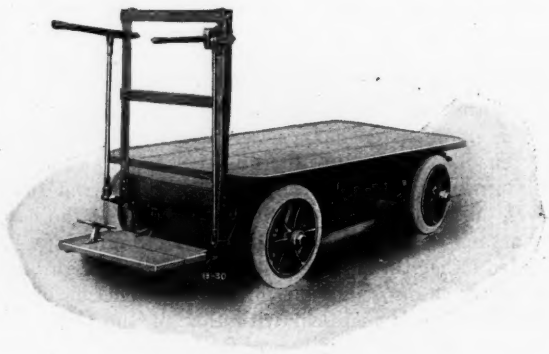
STORAGE BATTERY OPERATES TRUCK OF 4000 LB. CAPACITY AT SPEED OF 5 MI. PER HR.

THE Hunt storage battery industrial truck, illustrated in the accompanying photograph built by the C. W. Hunt Co., Inc., of New York is designed for conveying heavy material around manufacturing plants, steam shop and railroad terminals, etc., where it can be run with the utmost flexibility; it can be put on elevators and conveyed to different floors, and can be run directly into box cars, which would be well-nigh impossible with a system of tracks.

These trucks are very compact and have a capacity of approximately 4000 lb. With this load, the maximum speed is about 5 mi. per hr. The storage capacity of the batteries is ample for an ordinary full day's working.

Either Edison iron and nickel cells or Exide lead cells are supplied. The storage battery cells are encased in a battery box of heavy steel, suspended by springs from the cross members of the frame. The entire section of the top of the truck over the battery box is removable, thus making the batteries readily accessible.

The motor is especially designed for vehicle service, with storage batteries, and drives the wheels through a differential of cut steel gearing, all enclosed in an oil and dust-proof housing. Ball and roller bearings are used throughout.



CONVENIENT STORAGE BATTERY TRUCK FOR INDUSTRIAL PURPOSES

The operator's platform is at the front of the truck as shown, from which the truck is steered by the right-hand lever. The other lever controls the motor and the brake is actuated by the foot pedal. When not in operation, the truck is always locked.

THE UNITED STATES CIVIL SERVICE COMMISSION announces an open competitive examination for laboratory assistant on Jan. 21 and 22, 1914. From the register of eligibles resulting from this examination certification will be made to fill vacancies in this position in the Bureau of Standards, Department of Commerce, Washington, D. C., at salaries ranging from $900 to $1200 a year, and vacancies as they may occur in positions requiring similar qualifications.

The Bureau of Standards is engaged in research and testing of weights and measures, standards, measuring instruments, and materials. The work is similar to that in the better class of industrial and scientific research laboratories. Competitors will be examined in the following subjects, which will have the relative weights indicated: General physics, 25; French or German, 10; practical questions on each optional subject chosen, 35; education, training, and experience, 30. Each applicant will be examined in as many of the optional subjects as he may desire, and must state in answer to question 1 of application Form 1312 the optional subjects in which he wishes to be examined. The following are the optional subjects in which examinations will be given: Electricity, electrical engineering, heat, mechanics, mechanical and civil engineering, optics, paper technology, textile technology.

An educational training equivalent to graduation from a college or university of recognized standing is a prerequisite for consideration for these positions. Persons who meet the requirements and desire this examination should at once apply for application Form 1312 to the United States Civil Service Commission. In applying for this examination the title, "Laboratory Assistant (Male)," should be used.

Spiroflo Surface Condenser

NEW BAFFLE AND TUBE ARRANGEMENT REDUCES CONDENSING SURFACE REQUIRED. DEAD TUBE SURFACE ELIMINATED. CONDENSATION RECOVERED AT MAXIMUM TEMPERATURE

THEORETICALLY the correct form of surface condenser is one having a triangular cross section, the exhaust steam being admitted over one of the sides, and the amount of surface exposed to the steam diminishing in proportion to the decrease in the quantity of steam to be condensed. If the air and noncondensible vapors are taken off at the apex of the triangle opposite the entering steam, practically all of the tubes will do an equal amount of work, thus increasing the efficiency of the tube surface as a whole. All of this has been accomplished in a cylindrical shell, as will be seen by referring to Fig. 1.

Steam enters tangentially through a perforated baffle plate opposite the exhaust inlet and is distributed over the whole length of the tubes by a rectangular steam dome. In order to bring the entering steam immediately into contact with a large percentage of the total tube area, large steam bleeders are provided between the tubes. A spiral partition or baffle is provided, causing the steam to take a spiral path and dividing the surface so that the area will be reduced in proportion to the decrease in the quantity of steam to be condensed. The interior of this spiral baffle serves as an air cooler and as a means for removing any water that may remain, the air being collected from over the full length of the steam space and removed at the 2 ends. In this construction, therefore, there is no chance for the formation of air pockets at the ends of the condenser. Such a collection of air would blanket a portion of the tube surface and prevent the steam from reaching it. For the purpose of removing any water that may be separated from the air, water-sealed drains are provided on the under side of the spiral baffle.

This condenser is arranged for 2 passes of the circulating water, the cold water entering on the side opposite the steam inlet, so that a part of it passes through the air cooler tubes. The partially heated water then passes through the tubes on the steam inlet side of the condenser, thus bringing the hottest water into contact with the entering steam. The condensing steam is removed from the bottom of the condenser.

Steam can enter either horizontally at the side, or vertically at the top, the condenser being furnished with various positions of the exhaust inlet, circulating water and condensation openings, to suit conditions. In Fig. 2 is shown the tube arrangement for a horizontal central exhaust inlet. If the steam enters horizontally at the side, the water of condensation can be recovered, under normal load, at a temperature about 1 deg. below the temperature of the vacuum; if at the top, about 5 deg. below, thus saving heat to be returned to the boiler.

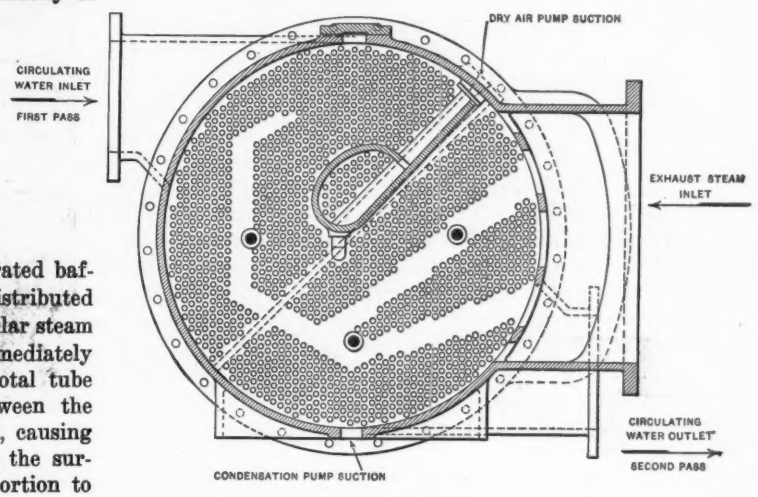


FIG. 2. ARRANGEMENT OF TUBES FOR CENTRAL EXHAUST

In comparing the sizes of the new and previous designs required for a given amount of work, it is found that the diameter of the former need be only about 0.9 that of the latter, assuming both condensers to be of the same length, with a consequent reduction in the tube surface.

Experiments conducted on a 3-pass counter flow surface condenser showed that from 60 to 70 per cent of the work was done by the third pass, which was adjacent to the entering steam; comparatively little by the second

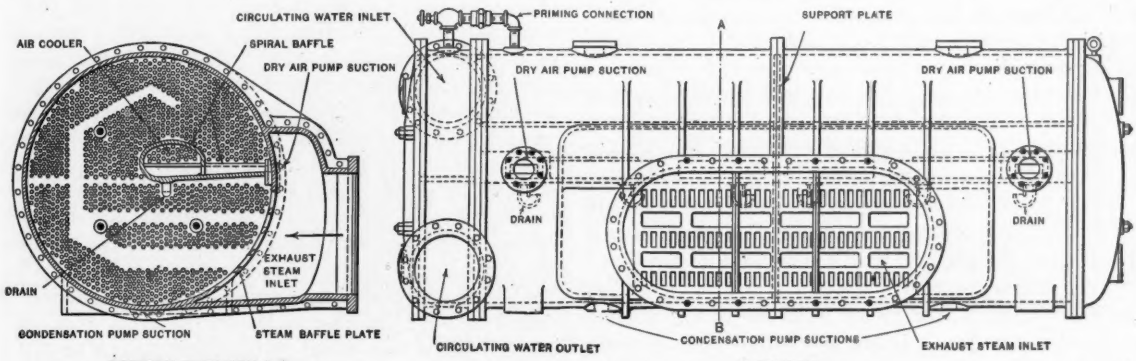


FIG. 1. ALBERGER SPIROFLO SURFACE CONDENSER

pass, and practically none by the first pass, which was most remote from the entering steam.

In the Spiroflo surface condenser, practically all of the surface in the second pass comes into contact with the entering steam, and the arrangement in the first pass is such that only the air and noncondensible vapors are left by the time the air cooler is reached.

Another feature in the design of this condenser is in the method of packing the tubes, which are expanded into one tube head, thus eliminating ½ the chances for leakage and preventing creeping. In the other tube head, the tubes are packed with a special fiber packing without sizing, held in place by means of a screw ferrule, without lugs, thus providing for expansion and contraction, so that, if the condenser is empty of water and is heated up to a moderately high temperature, as may happen with a leaky throttle valve, no leaks will result.

The Spiroflo surface condenser is manufactured by the Alberger Pump & Condenser Co., of New York, and is furnished with the following accessories: A condensation pump of either the centrifugal, steam-turbine driven, the centrifugal motor-driven, or the direct-acting reciprocating type; a dry air pump of either the crank-and-flywheel, reciprocating, close-clearance type, or the Hydroflo centrifugal type, using water as a medium for expelling the air; a centrifugal circulating pump, driven by either a steam engine, a steam turbine, a motor or a belt.

Locating Losses in Belt Transmission

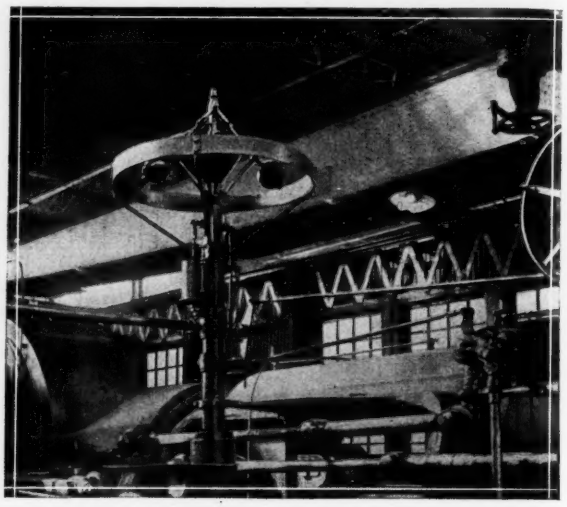
EVERY belt in a factory drops some power, and this may run from a nominal amount up to half the actual power delivered at the drive pulley. How to reduce this loss is an important study. With pulleys of correct diameter and width, and running at proper speed, the greatest loss occurs through slipping or binding of belts, such as may be caused by dry, hard belts running over slippery pulleys which must be drawn so tight, in order to transmit the required power, that they waste much power through friction. Belts should run loose and be kept in a natural soft condition, so that they will grip the pulley surface firmly.

Joints are also important, as, unless a joint is smooth and flexible, it requires considerable extra power to drive it over the pulleys, and a stiff joint works like a street-car with a flat wheel, giving a bump on the pulley every time it passes over. Such jerks use up unnecessary power. Leather laced joints are often open to criticism in this matter, and leather lacings are subject to breakage, which is annoying both as to labor and the delay in the operation of machines. Any other form of lacing must be strong and flexible as the belt itself, and should be quick and simple of application.

These points should be carefully investigated when making choice of a metal lacing, and care should be taken that the prongs close in so that they cannot work loose and catch the clothing or hands of the machine operator.

An example of such a joint is that made by the Clipper Belt Lacer, information about which may be obtained from the Clipper Belt Lacer Co., of Grand Rapids, Mich.

HEREWITH IS SHOWN a method illustrated in Engineering Magazine for preventing contact with revolving governor arms when they are so located as to constitute a



danger; also the ring acts as a safety guard in case a governor ball comes loose and flies off the arm.

IN THE LOCOMOTIVE, an account is given by C. R. Summers of an unusual explosion in a boiler in which the setting instead of the boiler blew up. There are 2 boilers in the battery, one being used at a time, and they had recently been set with great care to get a perfect installation. One of them was fired up, took the load off the old boiler installation and all went swimmingly until about 4 o'clock in the afternoon, when all the doors about the boiler setting were blown open and the fire scattered in all directions. The other boiler was immediately gotten under way, and about 4 o'clock the next morning, just to show that it was as good as its neighbor, an upheaval took place under that one, not so violent as under No. 2, so that the boiler could still be continued in service. By this time the first boiler had cooled down so that an investigation could be made. The concrete bottom of the ashpit was found blown up, the grate lifted off the bearing bars and dumped in the bottom of the furnace.

Following this clue, seepage from the outside was found to work its way under the concrete floor of the ashpit which was about 6 in. thick and after 10 hr. firing, the ashpit floor got hot enough to generate steam under it, which finally got sufficient pressure to blow up the ashpit bottom. The same thing had happened under the other boiler, only that as it was night and the fire was running lighter, the steam pressure was not so great and the ashpit was not thrown up so violently.

THE OHIO VALLEY CO. will erect a $750,000 power plant at Logan, W. Va., to supply power to the coal fields of that section.

PROPERTIES OF SATURATED AMMONIA.

By H. J. Macintire, Copyright, 1912 by Refrigerating World, New York.

Temperature. Degrees Fahr. t	Temperature. Absolute. T	Pressure in Pounds per Square Inch. Absolute. p	Pressure in Pounds per Square Inch. Gage. p'	Saturated Vapor. Volume in Cubic Feet per Lb. v	Saturated Vapor. Weight in Lbs. per Cubic Foot $\frac{1}{v}$	Liquid. Weight in Lbs. per Cubic Foot s	Heat of the Liquid from 32° F. q	Latent Heat. $H+q$ r	Total Heat of Dry and Saturated Vapor from 32° F. H	Entropy of Dry and Saturated Vapor. N	Specific Heat Saturated Vapor. cp
—40	420	9.25	—5.45	28.06	.0356	45.74	—77.80	597.3	519.3	1.251	0.505
—39	421	9.68	—5.02	27.16	.0369	.65	—76.76	596.7	519.9	1.249	0.505
—38	422	9.96	—4.74	26.26	.0381	.57	—75.72	596.0	520.3	1.246	0.505
—37	423	10.24	—4.46	25.37	.0395	.48	—74.68	595.4	520.7	1.244	0.506
—36	424	10.67	—4.03	24.48	.0409	.39	—73.63	594.7	521.1	1.241	0.506
—35	425	11.10	—3.60	23.59	.0425	.21	—72.58	594.1	521.5	1.239	0.507
—34	426	11.52	—3.18	22.83	.0438	.12	—71.54	593.4	521.9	1.237	0.508
—33	427	11.95	—2.75	22.08	.0452	45.04	—70.49	592.7	522.3	1.235	0.508
—32	428	12.37	—2.33	21.33	.0469	44.95	—69.44	592.1	522.6	1.232	0.509
—31	429	12.80	—1.90	20.58	.0486	.87	—68.39	591.4	523.0	1.230	0.509
—30	430	13.32	—1.38	19.83	.0505	.78	—67.34	590.7	523.4	1.228	0.510
—29	431	13.73	—0.97	19.30	.0518	.69	—66.29	590.1	523.8	1.225	0.510
—28	432	14.08	—0.62	18.77	.0531	.60	—65.24	589.4	524.2	1.223	0.510
—27	433	14.50	—0.20	18.24	.0549	.52	—64.18	588.7	524.2	1.221	0.511
—26	434	15.08	+0.38	17.71	.0565	.44	—63.13	588.1	524.9	1.219	0.511
—25	435	15.50	+0.70	17.19	.0582	44.35	—62.07	587.4	525.3	1.216	0.511
—24	436	15.94	+1.24	16.75	.0598	44.27	—61.01	586.7	525.7	1.214	0.512
—23	437	16.37	1.67	16.31	.0613	44.18	—59.96	586.1	526.1	1.212	0.512
—22	438	16.92	2.22	15.81	.0633	44.10	—58.90	585.4	526.5	1.212	0.513
—21	439	17.41	2.71	15.40	.0650	44.01	—57.84	584.7	526.9	1.209	0.513

STEAM TRANSMISSION AT CONSTANT QUALITY.

REHEAT DUE TO PRESSURE DROP EQUIVALENT TO RADIATION

PROPERTIES ON SATURATED AMMONIA.

By H. J. Macintire, Copyright, 1912, by Refrigerating World, New York.

Temperature. Degrees Fahr. t	Temperature. Absolute. T	Pressure in Pounds per Square Inch. Absolute. p	Pressure in Pounds per Square Inch. Gage. p'	Saturated Vapor. Volume in Cubic Feet per Lb. v	Saturated Vapor. Weight in Lbs. per Cubic Foot $\frac{1}{v}$	Liquid. Weight in Lbs. per Cubic Foot s	Heat of the Liquid from 32° F. q	Latent Heat. $H+q$ r	Total Heat of Dry and Saturated Vapor from 32°F. H	Entropy of Dry and Saturated Vapor. N	Specific Heat Saturated Vapor. cp
0	460	29.99	15.29	9.223	.1084	42.26	—35.33	569.9	534.6	1.166	0.526
1	461	30.74	16.04	9.015	.1109	.18	—34.25	569.1	534.9	1.164	0.526
2	462	31.50	16.80	8.812	.1134	.10	—33.16	568.4	535.2	1.163	0.527
3	463	32.27	17.57	8.614	.1160	42.02	—32.08	567.7	535.6	1.161	0.528
4	464	33.06	18.36	8.421	.1187	41.95	—30.99	566.9	535.9	1.159	0.528
5	465	33.86	19.16	8.233	.1214	41.87	—29.90	566.2	536.3	1.157	0.529
6	466	34.67	19.97	8.051	.1241	.79	—28.81	565.4	536.6	1.155	0.530
7	467	35.49	20.79	7.874	.1269	.71	—27.72	564.6	536.9	1.153	0.530
8	468	36.33	21.63	7.702	.1297	.64	—26.62	563.9	537.3	1.151	0.531
9	469	37.18	22.48	7.535	.1326	.56	—25.53	563.1	537.6	1.149	0.532
10	470	38.05	23.35	7.372	.1356	41.48	—24.43	562.3	537.9	1.147	0.532
11	471	38.93	24.23	7.213	.1386	.41	—23.33	561.6	538.2	1.145	0.533
12	472	39.83	25.13	7.058	.1416	.34	—22.24	560.8	538.6	1.144	0.534
13	473	40.75	26.05	6.907	.1447	.26	—21.14	560.0	538.9	1.142	0.534
14	474	41.68	26.98	6.759	.1479	.18	—20.03	559.2	539.2	1.140	0.535
15	475	42.63	27.93	6.616	.1511	41.11	—18.93	558.5	539.5	1.138	0.536
16	476	43.60	28.90	6.476	.1543	41.03	—17.83	557.7	539.8	1.136	0.537
17	477	44.59	29.89	6.340	.1576	40.96	—16.72	556.9	540.2	1.135	0.537
18	478	45.60	30.90	6.208	.1610	.88	—15.61	556.1	540.5	1.133	0.538
19	479	46.63	31.93	6.079	.1644	.81	—14.51	555.3	540.8	1.131	0.539

STEAM TRANSMISSION AT CONSTANT QUALITY

REHEAT DUE TO PRESSURE DROP EQUIVALENT TO RADIATION

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

PROPERTIES OF SATURATED AMMONIA

By H. J. Macintire, Copyright, 1912, by Refrigerating World, New York.

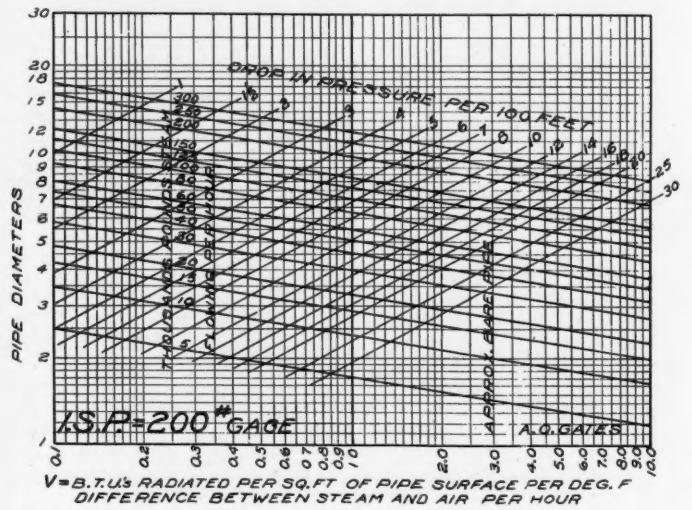
Temperature. Degrees Fahr.	Temperature. Absolute.	Pressure in Pounds per Square Inch. Absolute.	Pressure in Pounds per Square Inch. Gage.	Saturated Vapor. Volume in Cubic Feet per Lb.	Saturated Vapor. Weight in Lbs. per Cubic Foot	Liquid Weight in Lbs. per Cubic Foot	Heat of the Liquid from 32° F.	Latent Heat. H+q	Total Heat of Dry and Saturated Vapor from 32° F.	Entropy of Dry and Saturated Vapor.	Specific Heat of Saturated Vapor.
	T	p	p'	v	1/v	s	q	r	H	N	cp
20	480	47.68	32.98	5.953	.1679	40.73	—13.40	554.5	541.1	1.129	0.540
21	481	48.75	34.05	5.830	.1715	.66	—12.29	553.7	541.4	1.127	0.540
22	482	49.83	35.13	5.709	.1751	.59	—11.18	552.9	541.7	1.126	0.541
23	483	50.93	36.23	5.590	.1788	.52	—10.06	552.1	542.0	1.124	0.542
24	484	52.05	37.35	5.475	.1825	.44	— 8.949	551.2	542.3	1.122	0.543
25	485	53.19	38.49	5.363	.1863	40.37	— 7.835	550.4	542.6	1.120	0.544
26	486	54.35	39.65	5.255	.1902	.30	— 6.719	549.6	542.9	1.119	0.544
27	487	55.53	40.83	5.150	.1941	.23	— 5.602	548.8	543.2	1.117	0.545
28	488	56.73	42.03	5.047	.1981	.16	— 4.484	547.9	543.5	1.115	0.546
29	489	57.95	43.25	4.946	.2022	.09	— 3.365	547.1	543.7	1.113	0.547
30	490	59.19	44.49	4.847	.2063	40.01	— 2.245	546.3	544.0	1.112	0.547
31	491	60.45	45.75	4.750	.2105	39.94	— 1.123	545.4	544.3	1.110	0.548
32	492	61.73	47.03	4.655	.2148	.87	0.0	544.6	544.6	1.108	0.549
33	493	63.03	48.33	4.563	.2192	.80	1.125	543.7	544.9	1.107	0.550
34	494	64.35	49.65	4.473	.2236	.73	2.251	542.9	545.1	1.105	0.551
35	495	65.70	51.00	4.385	.2281	39.66	3.378	542.0	545.4	1.103	0.552
36	496	67.07	52.37	4.300	.2326	.60	4.507	541.2	545.7	1.102	0.553
37	497	68.46	53.76	4.216	.2372	.53	5.637	540.3	545.9	1.100	0.533
38	498	69.87	55.17	4.134	.2419	.45	6.768	539.4	546.2	1.098	0.554
39	499	71.31	56.61	4.054	.2467	.38	7.901	538.6	546.5	1.097	0.555

PROPERTIES OF SATURATED AMMONIA

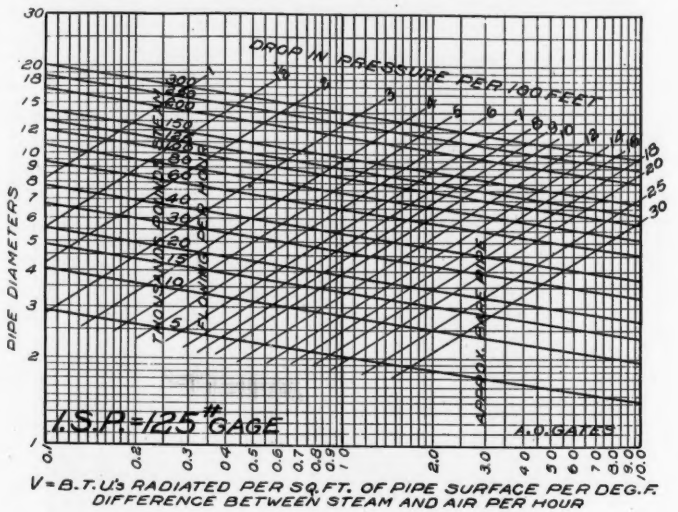
By H. J. Macintire, Copyright, 1912, by Refrigerating World, New York.

Temperature. Degrees Fahr.	Temperature. Absolute.	Pressure in Pounds per Square Inch. Absolute	Pressure in Pounds per Square Inch. Gage.	Saturated Vapor. Volume in Cubic Feet per Lb.	Saturated Vapor. Weight in Lbs. per Cubic Foot	Liquid Weight in Lbs per Cubic Foot	Heat of the Liquid from 32° F	Latent Heat. H+q	Total Heat of Dry and Saturated Vapor from 32°F.	Entropy of Dry and Saturated Vapor.	Specific Heat Saturated Vapor.
t	T	p	p'	v	1/v	s	q	r	H	N	cp
—20	440	17.91	3.21	15.00	.0667	43.92	—56.78	584.0	527.3	1.207	0.514
—19	441	18.41	3.71	14.61	.0685	.84	—55.71	583.4	527.6	1.205	0.514
—18	442	18.92	4.22	14.24	.0703	.75	—54.65	582.7	528.0	1.203	0.515
—17	443	19.44	4.74	13.88	.0721	.67	—53.59	582.0	528.4	1.201	0.516
—16	444	19.97	5.27	13.53	.0739	.58	—52.52	581.3	528.8	1.199	0.516
—15	445	20.51	5.81	13.19	.0758	43.49	—51.46	580.6	529.2	1.197	0.517
—14	446	21.06	6.36	12.86	.0777	.41	—50.39	579.9	529.5	1.195	0.517
—13	447	21.62	6.92	12.55	.0797	.33	—49.32	579.2	529.9	1.193	0.518
—12	448	22.19	7.49	12.24	.0817	.24	—48.25	578.5	530.3	1.190	0.518
—11	449	22.77	8.07	11.95	.0837	.16	—47.18	577.8	530.6	1.188	0.519
—10	450	23.36	8.66	11.66	.0857	43.07	—46.11	577.1	531.0	1.186	0.520
— 9	451	23.96	9.26	11.38	.0878	42.99	—45.03	576.4	531.4	1.184	0.520
— 8	452	24.58	9.88	11.11	.0900	.91	—43.96	575.7	531.7	1.182	0.521
— 7	453	25.21	10.51	10.85	.0922	.83	—42.89	575.0	532.1	1.180	0.521
— 6	454	25.85	11.15	10.60	.0944	.75	—41.81	574.3	532.5	1.178	0.522
— 5	455	26.50	11.80	10.35	.0966	42.67	—40.73	573.5	532.8	1.176	0.522
— 4	456	27.16	12.46	10.11	.0989	.58	—39.65	572.8	533.2	1.174	0.523
— 3	457	27.84	13.14	9.878	.1012	.50	—38.58	572.1	533.5	1.172	0.524
— 2	458	28.54	13.84	9.654	.1036	.42	—37.50	571.4	533.9	1.170	0.524
— 1	459	29.26	14.56	9.436	.1060	.34	—36.41	570.6	534.2	1.168	0.525

STEAM TRANSMISSION AT CONSTANT QUALITY
REHEAT DUE TO PRESSURE DROP EQUIVALENT TO RADIATION


DROP IN PRESSURE PER 100 FEET
PIPE DIAMETERS
I.S.P.=200 # GAGE
A.O. GATES
V=B.T.U's RADIATED PER SQ.FT. OF PIPE SURFACE PER DEG. F DIFFERENCE BETWEEN STEAM AND AIR PER HOUR

STEAM TRANSMISSION AT CONSTANT QUALITY
REHEAT DUE TO PRESSURE DROP EQUIVALENT TO RADIATION


DROP IN PRESSURE PER 100 FEET
PIPE DIAMETERS
I.S.P.=125 # GAGE
A.O. GATES
V=B.T.U's RADIATED PER SQ.FT. OF PIPE SURFACE PER DEG.F. DIFFERENCE BETWEEN STEAM AND AIR PER HOUR

H. C. Meinholtz

HERMAN CHARLES MEINHOLTZ was born February 7, 1868, at Saint Louis, Missouri, and died there December 24, 1913. He attended public school through the eighth grade, entering the Manual Training School in the fall of 1883, from which school he was graduated in 1886. After a few months as assistant in the Washington University Testing Laboratory under Professor J. B. Johnson, and a few more months as time-keeper for Shickle, Harrison & Howard, he entered the employ of the Heine Safety Boiler Co., at the age of 19 as draftsman, and was continuously connected with that company up to the time of his death.

At the beginning of his connection with the Heine Co., it was in its infancy, and he literally grew up with it, coming in contact with every phase of the business, although his work was mainly in connection with the practical side.

He was made superintendent in 1895 and vice-president in 1907. He had entire charge of the company's shop when it was established in 1899, and under his general direction the new factory was designed and built in 1909, and had since been under his direct supervision.

Although of a modest and unassuming disposition, he made many friends and was a keen observer and judge of men. He was by nature honest and courageous, and while slow to form decided opinions, after having once arrived at a conclusion he very persistently maintained it, and his judgment was usually justified by the results.

He was a member of the Engineers' Club of St. Louis, and of the A. S. M. E. In the latter, he was serving on a committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service.

In 1891 Mr. Meinholtz married Miss Minnie Eller, and is survived by her and 5 children.

Books and Catalogs

HARPERS' BEGINNING ELECTRICITY, by D. C. Shafer, 275 pages, in cloth binding with full illustrations, New York, 1913, price $1.00. A simple book for the boy who is interested in electricity and wants to know about the making and use of static electric machines, batteries, spark coils, telegraph and telephone installations, and the use of small motors and dynamos. Particularly well adapted for this special field.

HARPERS' WIRELESS BOOK, by A. H. Verill, 185 pages, fully illustrated, in cloth binding, price $1.00. New York, 1913.

An explanation for the youngster interested in wireless apparatus of how the wireless works, the instruments for sending and receiving, how to build and use wireless apparatus and the operation of wireless telephones. Clearly told and illustrated and with the actual experience of one boy who made his own wireless outfit, giving complete directions so that anyone else can follow them.

PITTS & KITTS Mfg. & Supply Co. has just issued a new loose-leaf catalog, showing the lines of the 10 manufacturers that they represent. The catalog is now ready for distribution, and will be sent out upon application to the Pitts & Kitts Mfg. & Supply Co.

FROM THE National Tube Co. is received a Safety Calendar which will be distributed to every one of the company's employes, approximating 30,000, as a daily reminder of the importance of safety precautions. The reproduction herewith shows the picture in which the safety idea is summarized, and this is emphasized by the phrase, "Taking no chances." Ideas brought out in the mottoes on separate leaves for the different months are as follows: "A Danger Sign Means That the Danger is Real, and Men Must Give Heed to the Warnings." "It Is Better to Be Careful a Thousand Times, Than to Be Injured Once." "When You See a Man Acting Carelessly, Tell Him About It and Don't Be Afraid of

Hurting His Feelings." "Neglect of Slight Injuries Often Results in Blood Poisoning, Don't Neglect Small Injuries, But See a Physician." "Eyes Are Valuable. Wear Goggles When Working Where Chips or Sparks May Fly." "Help to Keep the Mill Clean—A Dirty Mill Means Accidents." "Working in a Reckless Way Is Not Bravery, and People Who So Regard It Are Now Being Considered as Fools." "Find Out Special Dangers to Be Avoided When Starting on New Work. New Employes Are More Likely to Be Injured Than Old Employes." "Wrestling or Fooling on Mill Premises and Fooling with Machinery or Tools Is Dangerous. Careless Handling of Materials in a Steel Mill Produces More Accidents Than Any Other Single Cause. Remember This When Moving or Handling Material."

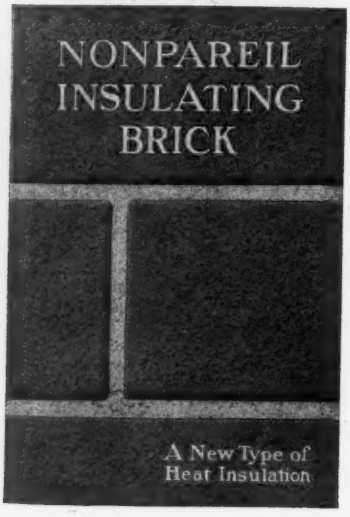
The calendar is beautiful, as well as being an important effort to reduce danger and promote the safety idea.

NEW CIRCULARS, describing and illustrating a number of varieties of single-acting triplex pumps, have been received from The Sandusky Foundry & Machine Co., Sandusky, Ohio.

FULTON-TOSI oil engines, modern European Diesel type, are described in an illustrated pamphlet recently received. Diagrams show the engine direct connected to ammonia compressor and different types of pumps, etc. The bulletin is No. 800, issued by Fulton Iron Works, of St. Louis.

ON THE PRESS, for the Simplex Wire & Cable Co., Boston, is a 92-page booklet which "Just fits the pocket," as well as the needs of every electrical man who has anything to do with wiring problems. It is full of tables and other information of all sorts about insulated conductors and other matters electrical, and is equipped with an unusually complete index. Printed on a fine thin paper, and bound with stiff covers, the book is to be distributed gratis to those who ask for it.

ARMSTRONG CORK CO., Pittsburgh, Pa., has just issued a booklet, entitled "Nonpareil Insulating Brick." It describes a new product, designed for the insulation of boiler settings, furnaces, breechings, stacks, kilns, bake-ovens, etc., to supply the need for a heat-insulating material combining low-heat conductivity with mechani-



cal strength sufficient to enable it to be built in as a part of the structure itself. Drawings indicate how Nonpareil brick may be used in the installation of typical boiler and furnace settings.

STORAGE BINS, an attractive pamphlet from Arthur G. McKee, Contracting Engineer, Cleveland, O., gives an illustrated description of the Baker patent suspension type storage bin.

SANGAMO METERS, illustrated in a 32-page bulletin, No. 36, include the mercury motor ampere-hour meter. Some advantages of mercury flotation are enumerated and ampere-hour meters for general service are discussed. The manufacturer is the Sangamo Electric Co., Springfield, Ill.

MESTA MACHINE CO., Pittsburgh, has recently issued Bulletin K, on gears and rolling mill pinions.

THE FISHER GOVERNOR CO., of Marshalltown, Iowa, has just issued its new catalog, which is ready for distribution by its eastern distributors, the Pitts & Kitts Mfg. & Supply Co. Copies will be sent upon application.

A NEW BULLETIN, No. 128, from Chandler & Taylor Co., Indianapolis, Ind., describes and illustrates that company's enclosed type, self-oiling steam engines, in simple, tandem and cross-compound types, for direct connection to electric generators.

CIRCULAR A-C 6, from The Gardner Governor Co., Quincy, Ill., contains 8 pages on Gardner horizontal duplex air compressors.

SEVERAL KINDS OF France Vanadium metal packing are illustrated on the 1914 calendar of France Packing Co., Tacony, Philadelphia.

BULLETIN 211, from The Griscom-Russell Co., 90 West St., New York, describes and illustrates the company's improved Massillon open feed-water heater.

FIRST INAUGURATION of Washington, a colored reproduction of the original painting by De Land, decorates the new calendar of American District Steam Co., North Tonawanda, N. Y.

AN ATTRACTIVE CALENDAR in colors was recently issued by the Ashton Valve Co. Copies may be obtained by sending 10 cents to the company, at 271 Franklin St., Boston, Mass.

THE CLING-SURFACE CO., of Buffalo, N. Y., has a special calendar for N. A. S. E. men, and, as long as the supply holds out, will be glad to supply a copy to any member who asks them for one.

ENGINEERING DEPARTMENT, National Lamp Works of General Electric Co., has recently published a comprehensive bulletin, No. 20, on Industrial Lighting, which deals with the different factors that must be given consideration in the design and operation of an industrial lighting installation. The effects of voltage conditions on the operation of lighting units are clearly explained. Curves showing the performance of incandescent lamps in actual practice are given. Different types of reflectors are discussed at length along with their distribution curves. The effect of accumulation of dust on reflectors of different types is illustrated graphically. The principles of illumination design and the method of figuring operation cost are clearly outlined. The application of modern methods of illuminating engineering is shown by a number of illustrated installations with complete data on each.

The information is authoritative and given in a concise and direct manner that will appeal to readers. Copies may be secured by addressing the Engineering Department, National Lamp Works, of General Electric Co.

FORT WAYNE TRANSFORMERS, Type A, are described in Bulletin No. 1147, superseding No. 1118, from Fort Wayne Electric Works of General Electric Co., Fort Wayne, Ind.

Bulletin No. 1145, from the same company, supersedes Bulletin 1113 on Type ML, 3-bearing, belted, direct-current generators with balance wheels.

Instruction Book No. 3056 supersedes No. 3048 on oil transformers.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., is issuing a calendar whose illustration shows a 12-in. gun in action at Fort Wadsworth, New York harbor, Brown pyrometers being used on the furnaces at the Washington navy yard for annealing the guns. The company will be glad to send this calendar on request.

A NEW MAP of the western part of the United States is sold by the Superintendent of Documents for 15 cents. This map measures 20 by 28 in., and shows the principal railroads, the national parks, the Indian reservations, national monuments, reclamation projects and the location of surveyors-general and local land offices. Remittances should be by money order, payable to the Superintendent of Documents, Government Printing Office, Washington, D. C., or in cash. Checks and postage stamps cannot be accepted.

A STRIKING panoramic view, in 6 colors, of Crater Lake, National Park, is now for sale by the Superintendent of Documents, for 25 cents. This view shows the park as it would appear to an observer flying over it, the ridges, peaks and valleys being shaded and colored in order to show the relief; it measures 16½ by 18 in., and has a horizontal scale of one inch to the mile. Remittances for this publication should be by money order, payable to the Superintendent of Documents, Government Printing Office, Washington, D. C., or in cash. Checks and postage stamps cannot be accepted.

IN BULLETIN No. 69, of the Bureau of Mines, by F. W. Horton, entitled "Coal Mine Accidents in the United States and Foreign Countries," which has just been issued, is found statistical information concerning the production, the number of men employed and the number of men killed in each state since 1896. From 1896 to 1907, the number of men killed per 1000 employed gradually increased with only slight fluctuation; the number killed per 1,000,000 short tons also increased, but the rate fluctuated over a wider range.

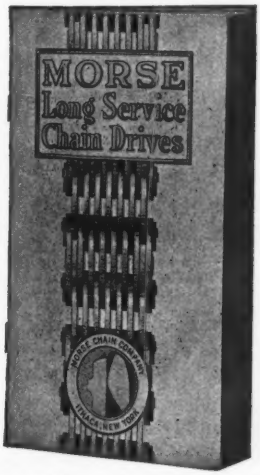
In 1896 each man employed produced 2.64 tons coal a day, whereas in 1907 the daily production of each man was 3.06 tons, an increase of 16 per cent.

Since 1907 there has a been a marked decrease in the number of fatalities at the coal mines. This general improvement has been brought about by a combination of causes, the principal one of which has been more efficient and effective mine inspection on the part of the State Mining Department and the State Mine Inspectors throughout the country, supplemented by greater care on the part of both operators and the miners. The investigative and educational work of the Bureau of Mines has kept both the operator and the miner alive to the various dangers connected with coal mining, and has shown what precautions should be taken to avoid these dangers. As a result of these educational features, mining companies are organizing safety committees; providing emergency hospitals, training men in first aid and rescue work, so that in case of a disaster they are equipped to cope with any ordinary accident.

Copies of this bulletin may be obtained by addressing the Director, Bureau of Mines, Washington, D. C.

GENERAL ELECTRIC CO. has recently issued Bulletin A4131, describing its storage battery locomotives. The bulletin outlines the general conditions under which the use of such locomotives are desirable or advantageous, and illustrates and describes various devices and sizes which have been built and placed in service. The bulletin is accompanied by a data sheet for the use of those who wish further information on this subject.

PUBLICATION NO. 12, entitled "Morse Long Service Chain Drives," was recently issued by Morse Chain Co., Ithaca, N. Y. The pamphlet illustrates and gives short descriptions of typical Morse silent chain drives,



showing their durability and efficiency for long periods of time, and describes the design and operation of the chains.

"A HOT WATER METER Is Essential to the Economical Management of a Boiler Plant," is the theme of a 48-page booklet issued by the Harrison Safety Boiler Works, 3144 N. 17th St., Philadelphia, Pa., and devoted to Cochrane hot-water meters and metering heaters (combined open feed-water heaters and hot-water meters). The means of measurement employed in these meters is the V-notch weir, the head on the weir being measured and recorded by a special form of instrument producing a rectangular chart with uniform divisions, from which the flow at any instant, also the total flow for a given period, may be taken off. By putting the weir within the closed chamber, it is possible to meter water at any temperature, as 212 deg., or above when operating under back pressure. Where the meter is combined with the open feed-water heater, the settling chamber or water storage space of the heater serves as the still water or approach chamber for the weir, thus saving in space occupied the first cost, as well as in complication of piping, etc., as compared with an independent meter. The illustrations show a number of meters of different sizes and forms, notably a combination of a metering hot well and 2 metering heaters of a total capacity of 1,200,000 lb. of water per hour supplied to the New York Edison Co. The inflow and outflow chambers of the metering heater serve to absorb pulsations due to the action of reciprocating pumps, insuring legible records, and no extra elevation of the heater above the meter, or of the latter in turn above the hot well and pumps, is required, as with independent meters. The

pamphlet concludes with directions, tables and forms for keeping account of steam boiler economy. The engineer who is interested in improving the efficiency of plants under his supervision will find this booklet of value, and may obtain it by writing to the company.

Trade Notes

THE MONASH NOISELESS SYSTEM of Vacuum Heating is to be installed in the M. L. Brede Office Bldg., in Chicago, to be operated by a Beach-Ruff vacuum pump, driven by a direct-current motor with Cutler-Hammer Mfg. Co.'s automatic control.

THE MOST COSTLY municipal building is that of New York City. The quantity of material used in construction reaches stupendous figures. For instance, to cover the maze of pipes which thread this building requires 27 carloads of pipe-covering material. The various lines covered include steam, hot water, ventilating, cold water and ice water for drinking purposes. This contract was awarded to the H. W. Johns-Manville Co., New York.

GRATON & KNIGHT MFG. CO., of Worcester, Mass., has recently purchased and equipped a branch factory at Detroit, Mich., taking over the plant and business of the Wayne Belting Co., at 112 Second Ave., and transferring the equipment to 266 Jefferson Ave., East, where the same lines of leather belting and automobile specialties will be manufactured which have heretofore been produced at Worcester, the new factory being in charge of C. F. Urquhart, and working especially for the Michigan trade. This will give the Graton & Knight Mfg. Co. added facilities for taking care of orders in the Central West, and also for doing repair work for that region.

A NEW GASKET MATERIAL on the market, made by the Kern Commercial Co., of 114 Liberty St., New York, consists of a braided asbestos tubular cord with a composition metal wire in the center, and comes coiled, like a rope. From this the gasket is made up by coiling in a flat coil to the shape desired. The packing is flexible, and the gasket can be shaped to round, square, oblong, triangular or other shapes, as may be required. The coiling can be done without the use of tools, and, of course, just sufficient is used each time to make up the required gasket so that there is no waste. The packing, which is called Sparsam, is stated by the makers to be proof against oil, fats, acids, alkali, chlorine, ammonia or superheated steam up to 720 deg. F., and comes in thicknesses from 3/32 to 3/8 in.

WHILE ITS sales for the first 6 months of the year 1913 have shown gratifying gain over the corresponding months of 1912, the results during the last 6 months of the year were not quite as satisfactory. Nevertheless, the L. S. Starrett Co., of Athol, Mass., has found the policy adopted last year to be so satisfactory that it voted, on December 10, 1913, to pay each employe as soon as possible after the 1st day of January, 1914, a sum equal to 2 per cent of the amount of wages paid to him during 1913. Needless to say, this action is greatly appreciated by the employes and comes as pleasant news of activity in the manufacturing field.

PRACTICAL ENGINEER

Trade-mark reg. U. S. Pat. Office.

SEMI-MONTHLY

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.
In Canada, subscription price $1.75 a year.
Foreign Countries, subscription price $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 S. Dearborn St., Chicago, Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.

ADVERTISING RATES

Display

Full page, one year, each insertion, $60.00.
Half page, one year, each insertion, $35.00.
Quarter page, one year, each insertion, $20.00.
Eighth page, one year, each insertion, $12.00.
Front cover, $150.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used but no heavy black and white plates.

Invoices are rendered monthly and subject to 2 per cent discount within 10 days.

Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 23,500

Technical Publishing Co.
537 S. Dearborn Street
Chicago

Position Wanted

POSITION WANTED—Chief engineer of wide experience in large plants; with first class license for Ohio and chief from U. S. Government for Marine Engineer. Solicits correspondence from large manufacturing concerns in view of locating with same. Address C. E. Hardy, 247 Forer St., Lockland, Ohio. 1-15-1

POSITION WANTED—In power plant where there is a chance for advancement. I. C. S. student. Age 19. Some experience with steam. Address Darrell Flora, Greene, Ia. 1-15-1

WANTED—Position as chief engineer in small plant or assistant in large plant. Have Minnesota license and can do wiring. Either steam or oil engines preferred. Otto Donath, Lakefield, Minn. 1-15-1

POSITION WANTED—With a company manufacturing and erecting. 15 years' experience in water, light and heating plants. In present place 4 years chief engineer. Age 33. Address Box 312, Bluffton, Ind. 1-15-1

POSITION WANTED—By first class fireman or assistant engineer. 7 yrs'. experience with fire and water tube boilers and Corliss engines. Address Box 330, Practical Engineer. 1-15-1

POSITION WANTED—As assistant engineer or will fire, wipe or oil in some electric light plant or manufacturer which has electric machinery in connection; can give good reference; strictly sober; am student of I. C. S.; some experience; hold first class license; will accept a small salary to begin with and chances of a raise as I advance. Address Robert Pieper, Route 5, Houston, Minn. 1-15-1

Wanted

MANUFACTURERS are you satisfactorily represented in Northern Ohio? We are in position to take on several representative accounts and would be glad to consider propositions with this in view. Our men call on Hardware Jobbers, Mill Supply Houses, Manufacturers and large Consumers in Ohio, and surrounding territory. Whitney Mfg. Co., 1110 St. Clair Ave., Cleveland, Ohio. 1-15-1

IF YOU RECOGNIZE the value of approved specialties in an engine and boiler room as a means of higher efficiency; if you believe in this sort of thing to the extent that you think you could sell a well-known boiler specialty in your territory for an old established manufacturer in the power plant field, write and tell us all about yourself. On receipt of your letter we will outline our proposition in full. Address Box 324, Practical Engineer. tf.

WANTED—EVERY ENGINEER to have our pamphlet for setting valves on Corliss Engines, single and compound, with one or two eccentrics. Sent free. Lindstrom's Machine Works, 200 South Third St., Allentown, Pa. tf.

WANTED—Second-hand 14x30 Corliss engine, 10-ft. band wheel, outside bearings. Must be in first-class condition. Give full dimensions and price. James E. Nelson care Udell Works, Indianapolis Ind. 1-1-2

WANTED—Every local Engineers' Association to have an assortment of valuable power-plant books—Secretary write at once, for full particulars. Address Dept. C., Practical Engineer, Chicago.

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write Subscription Dept. They will start you in at once.

WANTED—ALL STEAM USERS to have clean boilers without using compounds or chemicals in any form. Write "Otis," No. 317 Norfolk Ave., Buffalo, N. Y. tf.

WANTED—Secretary of local Engineers' Association to write us at once in regard to a very interesting proposition. Address Practical Engineer, Circulation Department.

Help Wanted

HELP WANTED—Desirable positions carrying salaries $2,500 to $10,000; technical, mechanical, executive, administrative, professional; can be negotiated for, confidentially, through undersigned counsel. Strictest privacy and safety assured. The difficult, unusual case particularly invited. Send address only, in confidence, for preliminary details. R. W. Bixby, Lock Box 134-56, Buffalo. 1-15-1

WANTED—An additional subscription solicitor wanted to cover towns in the state of Indiana. Excellent chance to earn extra money. Write to Subscription Department. tf.

For Sale

CORLISS ENGINES—20x42 Hughes & Phillips Corliss engine; wheel, 12 ft. by 28 in.; in perfect condition; $800 f.o.b. cars New York. 16x36 Hughes & Phillips Corliss engine; wheel, 12 ft. by 19 in.; in perfect condition; $575. Duzets & Son, 50 Church St., New York. Send for complete "Bargain List." 1-1-2

OUR MODERN BLUE PRINT CHART method of electrical wiring. Write for information. Electrical Wiring Diagram Co., Box F173, Altoona, Pa. 11-15-12

Patent and Patent Attorneys

THE PATENTOME is free. An education in obtaining patents. Established 1865, Anderson & Son, Attorneys, 710-7th St., Washington, D. C. 1-15-1

PATENT WHAT YOU INVENT. It may be valuable. Write me. No attorney's fee until patent is allowed. Estab. 1882. "Inventor's Guide" FREE. Franklin H. Hough, 537 Loan & Trust Bldg., Washington, D. C. 1-15-2

PATENT SECURED or fee returned—Send sketch for free expert search and report as to patentability. Books on inventions and patents, and reference book sent free. John S. Duffie & Co., 607 F St., Washington, D. C. tf.

PATENTS THAT PROTECT AND PAY. Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for free search. Watson E. Coleman, Patent Lawyer, 624 F Street, Washington, D. C. tf.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill building, Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established, 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. tf.

PATENTS SECURED. Legal protection our specialty. Booklet free. Harry Patton Co., Suite 330, McGill Building, Washington, D. C. tf.

OFFICIAL Drawings Free. Patents procured or fee returned. Expert services. Send sketch for Free search. The Patent Exchange, Garban Bldg. Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for 3 free books. R. B. Owens, 28 Owen Bldg., Washington, D. C. tf.

Educational and Instruction

BUILD a 3-Horsepower Revolving Cylinder Motor. Light, simple. Detailed drawings, $1.00. M. S. Lewis, Colton, Calif. 1-15-1

PROF. ARTHUR BATEMAN, who has been a practical teacher for 11 years, in 4 different institutions, in 2 countries, teaches by mail Sanitary Engineering, Sanitary Inspection, Plumbing, Hygiene. Booklet free. Write Desk 2, Anglo-American Sanitary Correspondence College, 12 W. Ontario Street, Chicago, Ill. 1-1-4

ENGINEERS' POCKET MANUAL, 175 pages, edited by University of Tennessee, will be mailed every subscriber sending in one new subscription to Practical Engineer. Gilt edges; bound in leather.

Technical Books

WORLD'S Best Self-educational Books. Electrical, Mechanical, Scientific, Anything technical, common or unusual. Catalogues free. Explain subject thoroughly. C. Higene Co., Dept. N., 2441 Post St., San Francisco, Cal. 1-15-1

Miscellaneous

IF YOU ARE an operating engineer, we know the Fetta Hot Process Water Purifier will interest you. We would be glad to have your request for further information. Address the Fetta Water Softener Co., Richmond, Ind. tf.

ENGINEERS—DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

MAKE MONEY on the side. Here's your chance to work out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you. tf.

Sparks On The Advertising Pages

Included in the inventory, preceding a sale of every worth-while manufacturing business, is the *good will.*

Good will includes the *prestige, affection, confidence* and *satisfaction* which a firm has developed during its existence among its clientele. So important an asset is it in a large business that extreme steps are often taken to prevent the dissolving or changing of firm names which are connected with it.

One of the original partners of a large Chicago mail order house has not been identified with the firm since the beginning of its nation-wide trade. However, his name is on every box and advertisement sent out by it, for, when he withdrew from the firm, the remaining partners paid him a substantial sum for the privilege to continue the use of his name.

The largest brewing company in this country, for years paid a royalty to an humble brewer in Bavaria who had gained the reputation, among connoisseurs, of brewing an exceptionally good beer. This brewer received a percentage on every bottle of beer the company sold in America, simply for the use of the label he had used on his product in Bavaria. Finally he sold the label outright for a comfortable sum.

The most valuable *good will* assets are those of the firms which have been closely associated with advertising. It has been estimated that the *good will* of the Royal Baking Powder Co. is alone worth $6,000,000. In other words, should the Royal Baking Powder plant be destroyed (including all product manufactured), it would be a profitable investment for a manufacturer to pay $6,000,000 for the name and label to use on baking powder made in his plant.

The same simile might equally apply to the manufacturers of Sapolio, Singer Sewing Machines, Pear's Soap, and other firms, which, by constant advertising and distribution, coupled with a product of uniform high quality, have made their brands synonyms for satisfaction, the world over.

Advertising is an expensive proposition unless some value is obtained other than the profit on the immediate sales. *All advertisements are a cast after good will.* Commonly, they are written to create immediate action or purchase, with the *good will* to follow as a result of satisfaction, but there are, however, many advertisements which are a direct appeal for the *good will* of the people. The advertisements of the American Telephone and Telegraph Co., now appearing in the general magazines, come under this class; also many of those of the International Harvester Company.

The best reason why you should buy the machinery and other power plant equipment advertised in Practical Engineer is the very fact that it *is* advertised.

The interlocking nature of advertising and *good will* is such that if the advertising is to prove profitable the manufacturer *must* satisfy you. He cannot afford to slight design, workmanship or material for the sake of an increased immediate profit.